RUDIMENTS OF REASON;

OR, THE

YOUNG EXPERIMENTAL PHILOSOPHER:

BEING A SERIES OF

FAMILY CONFERENCES

IN WHICH THE CAUSES AND EFFECTS

OF THE VARIOUS

PHENOMENA

THAT NATURE DAILY EXHIBITS, ARE
RATIONALLY AND FAMILIARLY
EXPLAINED.

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RUDIMENTS

OF

REASON.

THE THIRD CONFERENCE.

HYDRAULICS AND HYDROSTATICS.

SIR THOMAS HOWARD.

AS the Conference we are about to enter upon, my dear children, is as eaſy in itſelf as it will be delightful to you, it requires very little previous knowledge. I therefore will not long detain you from Lady Caroline's more pleaſant part of the buſineſs. What I have to ſay, ſhall be compriſed in a very few ſhort principles.

Hydraulics is that ſcience which treats of the motion of fluids in general, but of water in a particular manner.

Hydroſtatics treat of the *weight* of liquids or fluids; of their *equilibrium*, and of their *force on other bodies*.

It is not only the whole maſs of fluids that is ſaid to weigh; they likewiſe weigh in themſelves; that is, the parts of which they are compoſed enter into the account.

The weight of one part of one and the ſame liquid is independent of the weight of any other part of that liquid.

The weight of liquids takes place and is exerted in every direction.

All the parts of the ſame fluid are in balance with each other, whether they be in one and the ſame veſſel, or in veſſels communicating with each other.

The *preſſure* of liquids is exerted upwards and downwards, as well as ſideways, not in proportion to their quantity, but in proportion to their height above the plane of the horizon, and to the width of the baſe which ſupports them.

The difference of weight or of denſity of two liquids is ſufficient to ſeparate their parts when mixed, if the effect be not hindered by other more powerful cauſes.

Many fluids or liquids, though of different natures, weigh againſt each other, in a proportion of their denſities and their heights.

Two liquids of different denſities balance each other, when having both of them the ſame baſe, their heights above the horizon are in an inverſe proportion with their ſpecific gravities.

The air is a fluid which weighs, and which exerts the preſſure of its weight in every direction, like all other liquids.

A ſolid body, wholly plunged in any liquid, is compreſſed on all ſides round; and the preſſure that it experiences is ſo much the more great, as its own depth and the denſity of the liquid are greater.

If the plunged body be more heavy than the volume of the liquid which it has diſplaced, its reſpective weight makes it fall to the bottom.

The weight that a ſolid body loſes, when plunged in a liquid, is equal to that of the volume of the liquid which it has diſplaced.

If the ſolid body weigh leſs than an equal volume of the liquid in which it is plunged, it partly ſwims; that part of it which is plunged in the water, is the meaſure of a quantity of the liquid, equal in weight to the whole body.

Specific gravity is only another term for the word *denſity*, which I have already explained to you; but in our preſent ſubject, I think it right to repeat the effect of the expreſſion.

Specific gravity is, then, the relation that the weight of a magnitude of one kind of body, has to the weight of an equal magnitude of another kind of body.

There are three ſhort rules which natural philoſophers have given on this ſubject.

The firſt is this: if two bodies be equal in denſity, and unequal in magnitude or volume, they will have their maſſes, their matter, or their weights, in a direct proportion to their magnitudes, that is, their weights will be like their volumes: if the magnitude of one body be double that of another, and the ſpecific gravity of both be equal, the weight of the firſt will be double that of the ſecond body.

The ſecond rule is this: if two bodies be unequal in denſity, but equal in magnitude, their weights will be in proportion to their denſities; that is, if the denſity of the firſt be double that of the ſecond, the weight of the firſt will be double that of the ſecond.

The third rule is: when two bodies are unequal in denſity and magnitude, their weights will be, in a proportion, compounded or made up of their denſities and their magnitudes; that is, you will not be able to know the reſpective weight of each, but by multiplying their denſity by their magnitude. If the magnitude of one body be marked by the figure 2, and its denſity by the ſame number; and if the magnitude of another body be denoted by the figure 4, and its denſity by the ſame number, the weight of the firſt body will be as much leſs than the weight of the ſecond body, as 2 multiplied by 2, that is 4, is leſs than 4 multiplied by 4, that is 16; now 4 is only the fourth part of 16: therefore, in the preſent inſtance, the weight of the firſt body will only be a fourth of the weight of the ſecond body: for, when two bodies differ both in denſity and magnitude, their weights are in a compound proportion of their denſities and volumes: of this, daily experience confirms the truth.

In this compariſon of the weights of bodies, one alone is generally conſidered as the ſtandard or the unit to which every other body is compared: and as rain-water is in all places pretty much the ſame, natural philoſophers have choſen this liquid as their term of compariſon.

It has been found by repeated experiments, that a cubic foot of rain-water weighed 62½ pounds averdupois; conſequently, 62½ pounds, divided by 1728, will be the weight of one cubic inch of rain-water.

The knowledge of the ſpecific gravities of bodies is of frequent and great uſe, in computing the weights of ſuch bodies as are too heavy, or too unweildy, to have them diſcovered by any other means.

Theſe few hints will be ſufficient to throw a light on the queſtions that Lady Caroline is now going to propoſe to you, and enable you, I have no doubt, to give her very ſatisfactory anſwers.

LADY CAROLINE.

Why, Mary, does a barge, or a bucket, ſink the moment it ſprings a leak; that is, when a ſudden aperture takes place?

MARY.

Becauſe the ſubſtance or matter of which thoſe veſſels is made, is ſpecifically heavier than the fluid which ſupports them: if the water can by any means introduce itſelf, and fill them, the whole together makes up a maſs, of which the weight exceeds that of an equal volume of water; and for this reaſon the veſſel muſt ſink and be loſt.

LADY CAROLINE.

All porous and ſpongious bodies, Mary, when long expoſed to the moiſture or humidity of the air, become a great deal heavier than they were. What cauſe produces this effect?

MARY.

Bodies of that nature, ſuch as wood, ſoft ſtones, the mould of the earth, and others, naturally imbibe every aqueous particle that touches them, by the addition of which foreign matter their weights are neceſſarily increaſed; but when the air becomes more dry, they loſe that weight in the proportion in which they exhale their moiſture.

LADY CAROLINE.

What is the reaſon, Frederic, that thoſe people who ſell by weight goods equally ſuſceptible of becoming moiſt or dry, ſuch as tobacco, indigo, ſugar, and others, are particularly careful to keep them in the cooleſt parts of their repoſitories?

FREDERIC.

I ſhould imagine, Madam, that it is in order to prevent an evaporation, which might turn out to be really detrimental to their traffic. Beſides, the very conſiderable quantity of aqueous particles with which theſe bodies become charged in ſuch cool places, is an effectual addition to their weight.

LADY CAROLINE.

The timber, William, allotted to the building of veſſels, ſwims at firſt, when thrown into the wet-dock; but by degrees it ſinks, and becomes at laſt hid beneath the ſurface of the water. Tell me how this may happen?

WILLIAM.

In courſe of time I ſhould imagine that the timber muſt be deprived of its ſalts, and other ſubſtances ſpecifically lighter than the liquid which immediately takes their place; and then the liquid, made up both of wood and water, equals, and even ſurpaſſes, in weight, the liquid which ſurrounds it; for it is a well-known truth, that the conſtituent parts of the lighteſt wood are more heavy than water. Cork itſelf ceaſes to ſwim after having been long ſteeped, becauſe then its parts diſunite, and do not any more make up a volume, as uſual, with much more void than ſolidity.

LADY CAROLINE.

How is it, Fanny, that hoar-froſt ſnow, and every other kind of watery congelation with which all trees and plants are ſo often covered, bear down the bodies they adhere to, and fatigue them much more than common rain-water does?

FANNY.

In general I have obſerved, that thoſe kinds of congelations thicken much more round the ſmaller branches than round the trunk: the weight, therefore, not only of the humidity, but of every foreign little ſubſtance, that the froſt fixes to the tree with this moiſture, attacks it in its weaker parts, ſo that at laſt the tree itſelf is deſtroyed in its branches.

LADY CAROLINE.

There are in many countries, Edward, natural grottos and caverns, in which there are ſeen vaſt quantities of ſtony concretions, which are formed drop by drop, and hang down from thoſe ſubterraneous vaults, like ſo many icicles formed by a thaw, under the roofs of houſes, or where-ever there is a gradual melting of ſnow: what can be the cauſe of this phenomenon?

EDWARD.

Thoſe ſtones to which people have given

the name of *ſtalactites*, are originally liquid, like the water in which their parts are conveyed. The firſt drop which remains hanging from the vault, adheres to it no more than is neceſſary to ſupport its own weight; but in proportion as its moiſture evaporates, it becomes ſolid, and able to bear the weight of other ſandy drops, which arrive at a ſimilar ſituation; ſo that at laſt a very conſiderable maſs hangs from the vault in ſpite of its own weight, for no other reaſon, than that it has become ſolid by the evaporation of the water, and the agglomeration of the little particles which now are faſtened to each other, by the means of that one which originally clung to the vault.

This operation of nature is very cloſely imitated by chandlers in general. They thrid in a parallel manner the eyes of the wicks upon long ſlender rods, and plunge them repeatedly into trays of melted tallow; or ſometimes pour from above the liquid wax all along the wick. This laſt uſage is generally recurred to in the making of large wax tapers, deſigned to be broader at the bottom than at the top: for it is eaſily ſeen, that the matter becoming cooler decreaſes in velocity towards the end of its fall; and great care is likewiſe taken not to employ it in too hot a ſtate, that, at every immerſion or pouring, the greater quantity of ſubſtance may adhere.

LADY CAROLINE.

How is it, Sophia, that a piece of ice of one pound weight does a great deal more harm when it falls, than an equal quantity of water?

SOPHIA.

When the water falls, the air, as it is a reſiſting medium, divides its parts; this diviſion increaſes the ſurface of the water, and very conſiderably retards the velocity of its fall; whereas the piece of ice, offering a leſſer ſurface to the reſiſting air, preſerves its rapidity, and by its impreſſion being more ſuddenly made, exerts its power at once, and thereby does much more harm than the water.

This anſwer may be extended to an angular or pointed body, which is a great deal more dangerous in its fall, than if it had been flat; for its whole effort is re-united againſt one ſmall ſpot; and, by a contrary reaſon, we are leſs in danger of being hurt, when we receive a cricket-ball, for inſtance, with hollow inſtead of extended hands.

LADY CAROLINE.

Why, Mary, does an inclined bottle, or a freſh tapped barrel, empty themſelves?

MARY.

The liquor they contain preſſes them in every direction, and, of courſe, forces its way out; for the very ſame reaſon, I have heard it ſaid, that a ſhip pierced by a cannon-ball, immediately leaks by her ſide, and will as infallibly ſink, as if the ſhot had been in the very bottom of her keel;

and the water will ſo much the more quickly ruſh in, as the ſea is higher above the hole.

LADY CAROLINE.

Here, Elizabeth, is a cup with a very ſmall hole at the bottom of it. How is it, that it becomes full, as I thus perpendicularly preſs it down in this baſon of water?

ELIZABETH.

The weight of the ſurrounding columns of air preſſes on the liquid, ſo as to raiſe it upwards. Thus, to draw water from very deep wells, people ſometimes make uſe of two buckets, tied to the two ends of one and the ſame rope, which runs round a ſpecies of pulley, that turns in ſuch a manner, as to let one bucket down while the other riſes. They are filled at the bottom by means of a kind of pump-ſucker, which opens to receive the water that preſſes upwards, but ſhuts when full, by the water that preſſes downwards.

LADY CAROLINE.

Why, George, when water is intended to be carried on by its own weight from one place to another, for the purpoſes of ſociety; why, I ſay, does the undertaking fail in ſucceeding, even when the ſpaces are perfectly level?

GEORGE.

It is abſolutely neceſſary that there be a ſlope, in order to ſurmount the reſiſtance of friction; and it is for this reaſon, that in all aqueducts, in all conduit-tubes, and in all canals, where it is meant that the water ſhould flow, workmen generally give the inclination or ſlope of one twenty-fourth part of an inch, to every fathom that they advance.

LADY CAROLINE.

Tell me, Kitty, how can water be made to aſcend, even into our very apartments, for the purpoſe of domeſtic convenience?

KITTY.

The water that we receive in this extraordinary manner is previouſly preſerved in reſervoirs of a higher ſituation, or runs over a higher ground than thoſe places to which it is intended to be conveyed; and this conveyance is effected by a continuity of ſloping tubes, lodged under ground, and directed to their ſeveral deſtinations; as all water, therefore, endeavours to riſe to a level with itſelf, it will forcibly mount up through the pipes of the ſeveral apartments, until it becomes at laſt equal to the height and level of the body of water from which it came.

LADY CAROLINE.

Why, Frederic, is it prejudicial to the owner of a pump, that the workmen ſhould, through ignorance, make the pipes intended to convey the water too ſmall?

FREDERIC.

The owner will receive a very ſmall portion of that water to which he is intitled, on account of the great increaſe of friction; for this kind of reſiſtance increaſes as the ſurfaces increaſe, and the internal ſurface of a ſmall tube proportionably exceeds that of a large one.

LADY CAROLINE.

I have ſeen, William, when on board of a pleaſure yacht, a very curious experiment tried, which I truſt you will be able to explain to me. The ſounding-lead, you know, is a large leaden weight, tied to the end of a very long rope. The gentleman who ſhewed the experiment, took firſt a common cylindrical quart glaſs bottle, perfectly empty, and having corked it with a cork ſecured by many folds of linen, and ſealed all round with ſealing-wax, in as exact a manner as could be done, he tied it to the end of the ſounding-lead. The empty bottle, dragged down by the weight of the lead, went to the bottom of the ſea, when we were at anchoring. He did the ſame thing with a round bottle, and an oval one; and when they were all hauled in, I was extremely ſurpriſed, as well as the reſt of the company, to ſee them all full of the moſt tranſparent water, and conſiderably more ſalt than the water on the ſurface of the ſea. The ſounding-lead had deſcended two hundred and twenty-five fathoms. Now, William?

WILLIAM.

Every fathom that the bottle deſcended added new ſtrata of water over it, and the preſſure of ſo enormous a weight continuing inceſſantly to act upon it, with weight always increaſing, forced through the very pores of the bottle, as well as through the wax and the cork, the acute and ſmall particles of ſalt, which, from the preſſure they are always in at ſo prodigious a depth, are urged by the ſurrounding particles and water, to ruſh in wherever there is leſs compreſſion: now, the pores of the bottle and cork offer pores enow to ſuch fine ſpicula, which, when entered, melt down into water, and ſoon fill the reſpective bottles, when the altitude and baſe of the ſea they were in, multiplied into each other, amounted to a ſtrength equal to produce ſuch an effect.

LADY CAROLINE.

How does water riſe, Henry, in thoſe pumps which act by a ſpecies of attraction?

HENRY.

The external air preſſes down upon the water, and in proportion as the ſucker, by being drawn upwards, exhauſts the internal air of the tube, the external air impels the water after it.

LADY CAROLINE.

I ſaw, Henry, a curious experiment performed by your father a conſiderable number of years back, which I hope you will be able to account for. He filled a very ſmall and long tube with a few pints of ale; this tube he placed on the ſluice, or, as it is commonly called, the bung-hole of a very large barrel, full of ale, and ſo placed in a copper trough that the liquor might not be loſt to a group of his tenants, whom he meant to regale by the experiment. He no ſooner placed the tube on the orifice, and poured the few pints in, but the large barrel inſtantly burſt. Well, Henry?

HENRY.

I am not ſure that I am right, but I ſhould imagine that when this ſmall tube or column is placed upon the aperture of the barrel, and the pints poured in, it becomes one continued body with the barrel itſelf, and having the barrel for its baſe, the tube acquires the ſame ſtrength as if it were equally broad along its whole height: for as fluids increaſe in preſſure by the increaſe of their altitude and baſe, you cannot augment one without communicating its weight to the other.

LADY CAROLINE.

I have here prepared two ſmall kegs, equal in ſize, and both equally full of water. I now beg the favour of Sir Thomas to pull out thoſe two ſmall bungs which cork up two apertures, exactly equal to each other, and when this ſhall have been effected, Elizabeth will be ſo good as give us an account of what ſhe obſerves?

ELIZABETH.

Are thoſe baſons, Madam, equal in contents, which you have placed to receive the water in each keg?

LADY CAROLINE.

They are, Elizabeth.

ELIZABETH.

I perceive then that the water of one of thoſe kegs ruſhes out with much greater rapidity than the water of the other: and I perceive that one baſon is almoſt full, while the other has received little more than half its contents. The reaſon of this muſt, I think, be, a circumſtance which your Ladyſhip has not mentioned to us, and that is, that the hole of one keg is a great deal lower than that of the other: there muſt therefore be a much greater weight above the water that flows from the loweſt hole, than there is on the water that iſſues from the higheſt, on account of the greater length of the column.

It is for this reaſon that all *jets-d'eaux*, or water-ſpouts, riſe and throw out in the proportion of the heights of the reſervoirs; and the elevation of the ſpout becomes leſs in the ſame proportion that its reſervoir empties itſelf. Hence it likewiſe follows, that all veſſels of uniform capacities, ſuch as cylinders, priſms, and others, never empty themſelves equally in equal times, when the flowing of the liquid takes place at the bottom of the veſſel. The reſpective quantities which flow during every minute of time, diminiſh in the exact proportion of the deſcent of the ſurface of the flowing liquor. For this reaſon, I ſhould think that the baſons of public reſervoirs ſhould be always religiouſly kept equally full, that individuals may not be wronged in their juſt allowances.

In the time of the vintage, when the

wine-tubs are broached, the iſſuing wine ſpouts farther, and in much greater quantity at firſt than towards the middle or the end of its flowing, for the above-mentioned reaſon, of the altitude of the liquid diminiſhing, the preſſure decreaſing, and the ceaſing of the fermentation of the ſpirit.

LADY CAROLINE.

Why, Kitty, during violent and long rains, do we ſee brooks conſiderably large, which had no previous exiſtence?

KITTY.

I ſuppoſe the ſame reaſon takes place in this inſtance. There are a great many ſprings whoſe ſurfaces lie much beneath the ſurface of the earth, and never make their appearance until long rains ſhall have raiſed the column of their waters, not only to a level with the earth, but ſhall have made them overflow, ſo as to feed for a ſpace of time the brooks they thus give riſe to.

LADY CAROLINE.

I take this ſmall bottle, Mary, full of lavender-water, and uncorking it, I lay it on its ſide. What do you obſerve?

MARY.

I perceive that the lavender-water has been a long time in coming out, but I now ſee it flow with increaſing ſwiftneſs: I believe the reaſon of this may be, that the air at firſt took ſome time before it could inſinuate itſelf into the neck of the bottle, and by that means proved a temporary obſtacle to the water's running out; but having once procured a paſſage, it forces its way on, and, by the elaſticity of its ſpring, urges the water more rapidly out.

LADY CAROLINE.

The air, Fanny, preſſes much more forcibly in the valley, than on the mountain; and water riſes to a much greater height in the firſt than on the laſt. What is the reaſon of this?

FANNY.

The ſame as before; the preſſure and the elevation are both owing to a longer column of air. I ſhould therefore on this occaſion think, that before clock-work had arrived at its preſent perfection, the inſtruments which were uſed for the meaſuring of time muſt have been very imperfect. The ancient *clepſydra* and the modern hour-glaſs, being only veſſels of which one part empties itſelf in a certain time of its water or of its ſand into another, can never give a diviſion of time to be truſted to; for, generally ſpeaking, the velocity of flowing ſubſtances depends not only on the perpendicular height of the fluid, but alſo on the quantity of friction, on the degree of fluidity, and on the proportion of denſity, which are all in themſelves very variable, and extremely difficult to be eſtimated.

LADY CAROLINE.

I have here a curious kind of crooked glaſs tube, ſomething, you ſee, like a pair of ſpring tea-tongs, with this difference, that one of the arms is ten times wider than the other. Both the arms of the tube communicate with each other, and having now poured this water into one, you ſee it riſe in the other to a height exactly equal; that is, though one arm holds ten times the water of the other, yet the ſmaller balances the greater. Account for this, George?

GEORGE.

All liquids of the ſame kind which have in any way immediate communication with each other, act againſt each other preciſely in the proportion of their heights. By being more or leſs wide, their reciprocal power is in ſenſe diminiſhed or increaſed, becauſe bodies of this nature act againſt each other, juſt in the degree they are preſſed. Now the preſſure they experience, is accurately and ſolely in proportion to their heights.

LADY CAROLINE.

I take this other crooked tube, one of

the arms of which is equally wide as the large arm of the other; but this other arm, you may perceive, is ſo minutely ſmall, that the width of its opening is but one thirty-ſixth part of an inch. I pour water in the large arm, but you may now ſee, that having entered the ſmall arm, it ceaſes to be level. Is not this againſt the general rule, Frederic?

FREDERIC.

I do not ſee how the general rule can in this inſtance take place; for the internal ſpace of the ſmaller tube is ſo extremely ſmall, that I have heard it called by Sir Thomas the capillary tube, from the reſemblance of its aperture to a hair, in Latin termed *capilla*. Now the very ſmall portion of water contained in this capillary tube, having more ſurface to contend againſt, and being more impeded and ſupported by the irregularities of the almoſt contiguous ſides of ſo narrow a tube, has ſcarce any force left, and muſt ſtand above the level, to be able to counterpoiſe the water of the large arm. This extraordinary exception to the general rule proceeds therefore from the extreme tenuity of the tube, and not from the capillary column of the contained liquid.

LADY CAROLINE.

Why, Sophia, does compreſſed water, ſuch as that contained in the narrow paſſages that lead into or out of mill-dams, accelerate its motion?

SOPHIA.

The lateral parts which meet the obſtacle in the contracted ſides of the little channel, are at the moment of their paſſage more compreſſed by the water that follows them, and inceſſantly pours on them. Being thus urged on and ſqueezed, they make a greater impreſſion on the parts which flow directly and freely in the center of the ſtrait, and the reſiſtance of theſe laſt parts is never felt, as there is an open paſſage for them to proceed. In this ſituation more water muſt flow in equal times, and therefore in thoſe narrow necks the increaſe of water will ever produce an increaſe of velocity; this may be exemplified by the ſlow motion of a river in the larger parts of its bed, and its extreme velocity when it ruſhes through the arches of a bridge; and I have heard you ſay, Madam, that if the mouth of a common ſquirt be ten times narrower than its body, it will acquire a tenfold velocity in the water it ſends forth.

LADY CAROLINE.

As you have made mention of the ſquirt, Sophia, I beg you would tell me by what means the water mounts into it?

SOPHIA.

When I place the orifice of the ſquirt in water, and draw the ſucker up, the water next the mouth loſes the ſupport of the air which I have extracted; it therefore becomes lighter, and muſt conſequently yield to the heavier parts which ſurround it, and heave it upwards. In general, all the weaker parts of any liquid aſcend, impelled as they are by the heavier and ſtronger parts which raiſe them.

Liquids of different kinds and of different weights never are level with each other, becauſe the heavieſt muſt deſcend and raiſe up and ſupport the lighter. This is the reaſon why we ſo often ſee little balls of air flowing rapidly up after each other in a decanter, where the water has been long kept; for the air that has gradually crept into it, being put in motion, flies to the ſurface to regain its natural ſituation, by means of the water's weight.

LADY CAROLINE.

I take this wine and water, and pour them into this glaſs. It is well known that the water is heavier than the wine, yet you ſee they both mix. How does this happen, Mary?

MARY.

Your Ladyſhip poured the water on the wine, and then they both immediately mixed; but had you gently poured the wine on the water, there would not have been a mixture without ſhaking them; but the reaſon that they really do mix, is, that they both acquire a velocity in their fall of ſtrength enough to divide their particles, to trouble their balance, to introduce themſelves into each other's pores, until friction exhauſts their motion, and renders them unable to diſentangle themſelves.

LADY CAROLINE.

I avail myſelf, Mary, of your ingenious hint of gently pouring the wine on the water, and now pour the water firſt into this glaſs; the conſequence I ſee is, that the wine ſtill goes to the bottom, and yet I have not ſhook them. How does this agree with your anſwer, Mary?

MARY.

If your Ladyſhip will indulge the wine with time to recover itſelf, and if you have not been over-haſty in the pouring of it out, I fancy you will ſoon ſee it aſſert its ſuperiority over the water: and I think I already ſee the little ruby ſtreaks re-aſcending and getting the better of the precipitancy of your hand.

SIR THOMAS.

You are perfectly right, my ſweet girl; the wine has already got to the top, and nothing but loſs of balance in the hand that pours it in could make it quit the ſurface: but that you may always be ſure of ſucceeding in this little experiment, I will beg the favour of Lady Caroline to cut an exceeding thin ſlice of ſtale bread, and lay it on the ſurface of a broad finger glaſs, half full of water, and then pour gently upon it as much wine as the finger glaſs will hold.

Her Ladyſhip I ſee has ſucceeded. Now, Mary, what do you obſerve?

MARY.

I obſerve that the wine is now wholly uppermoſt, and I think I can give a reaſon for it.

The motion it had acquired is by this ſtratagem of yours, Sir, almoſt inſtantaneouſly arreſted; and if there ſhould aught remain of motion, it becomes totally loſt by the filtering through the pores of the bread: it will therefore by its ſpecific lightneſs remain in that ſuperior ſituation.

LADY CAROLINE.

Let us ſee, William, if you can give as ingenious an account of what I am going to ſhew you, as my dear Mary has given of the laſt experiment. I have here a tumbler full of new milk, which I have purpoſely ſet aſide, that I might have your obſervations upon it, and the reaſon of what you obſerve?

WILLIAM.

I obſerve nothing but a circumſtance that daily happens; I ſee a very rich layer of cream on the top, made conſpicuous by the yellowneſs of its colour, while the pure white milk lies under to ſupport it.

The reaſon of which I take to be this; the particles of the cream are of a more adipous (fat or greaſy) nature, than thoſe of the milk, and conſequently leſs compact: they cannot be leſs compact without containing leſs matter; they cannot contain leſs matter without being leſs denſe; and if they are leſs denſe, they cannot be ſo ſpecifically heavy as the milk. The milk, therefore, muſt tend to the bottom, and the cream ſwim. Thus all fat, animal, vegetable, and mineral ſubſtances, when ſhaken with water, mix in it for a time; but the particles being infinitely leſs denſe, or ſpecifically heavy, they ſoon diſengage themſelves and riſe to the top; and the general method recurred to by people employed in theſe matters, is, to allow them time to extricate themſelves for the purpoſe of ſeparating them.

LADY CAROLINE.

We frequently ſee on the ſurfaces of ſtagnant pools, rich ſtreaks of various colours,

lours, which, in certain directions, emulate the tints of the rainbow. What is the reaſon of this, Henry?

HENRY.

The earth beneath the pool may be either bituminous, or ſulphureous, or both. In this caſe, the fat particles, being waſhed away from the bottom, riſe to the top through their ſpecific lightneſs, and muſt therefore reflect the rays of light as they form a continuity of ſurface, and perform in a manner the offices of mirrors. Waters in which clothes are waſhed, and ditches in which the carcaſes of dead animals are thrown, are likewiſe ſubject to have their ſurfaces covered with this ſpume.

SIR THOMAS.

Tell me, Edward, why does a fat animal, rational as well as irrational, excel a meagre one in the act of ſwimming?

EDWARD.

A drop of oil, a particle of any kind of fat ſubſtance, always lies on the ſurface of water: a larger quantity, therefore, of the ſame matter muſt have the ſame effect, ſince ſubſtances of that kind are leſs heavy than others. This reaſon comprehends another, which is, that adipous bodies have more vacuities and hollows, and partake more of the nature of bladders, the very eſſence of which, if I may be allowed the expreſſion, is the oppoſite of deſcent or ſinking. On this principle, a hog, or a bullock, run much leſs riſk of drowning, when thrown into the water, than a cat or a ferret.

LADY CAROLINE.

How does it happen, Kitty, that conſidering the impalpability of the air, and the palpability of ſtraws, bits of paper, and the groſſer kinds of exhalations, ſuch bodies, notwithſtanding, mount up to conſiderable heights in the air, and remain there for a long ſpace of time?

KITTY.

Their riſing into the air is owing to the motion of the air itſelf, when their weights are ſpecifically heavier, or even equal; but when their particles are ſo divided as to ſpread through a large portion of the air, they then are lighter, and will riſe and remain in the air till ſuch time as they diſſolve into rain, or are exhauſted by the heat of the ſun.

LADY CAROLINE.

This ſmall phial of oil has been for a long time laid aſide, and has of courſe collected a vaſt quantity of aerial particles: I now ſhake it, and the globules of air all mount to the top. What is the reaſon of this, Frederic?

FREDERIC.

There is no other reaſon, Madam, but that the air is lighter than the oil, as oil is lighter than water, as water is lighter than mercury; and ſo on.

LADY CAROLINE.

You ſee, Elizabeth, I have here beat up together a little oil and water, and have ſuffered the air to mix with them; the conſequence is, that they all three have loſt their fluidity. I now again whip a little cream with this white of an egg, and you may eaſily perceive that they too ceaſe to be fluid. What can be the reaſon of this?

ELIZABETH.

The friction increaſing in proportion as the ſurfaces are multiplied, the mixed liquors may be divided into ſo ſmall portions, that they may touch each other in too many points, and the difference of their weights, which can alone diſunite them, may not equal the friction, or, which is quite the ſame thing, the difficulty they meet with of diſengaging from each other.

It is for this very reaſon that oil and wine, when well beat up together, become ointment; and that the white of an egg, cream, &c. ſwell into a motionleſs froth: for the air is ſo extremely divided, and its mixture with thoſe liquids is ſo very intimate, that its ſpecific lightneſs is not ſufficient to looſen it from them.

To theſe reaſons I can add two other cauſes, which render the ſeparation of the parts ſo difficult; one is, the viſcoſity, which is greater or leſs in one ſubſtance than in another, but from which no ſubſtance is exempt: the other is, the ſympathy, or rather analogy, which is frequently found between two liquids, and which probably conſiſts in an adaption of parts, a likeneſs of magnitude, and a fitneſs of figure. Thus the ſpirit of wine once mixed with water can by no art be ever again ſeparated from it, while the oil of turpentine, which is not a great deal lighter, ſuffers no difficulty in being drawn from the water it was mixed with.

LADY CAROLINE.

Here is a little but very curious glaſs inſtrument,

ſtrument, George; it conſiſts of a ſmall tube of glaſs, above which there is a ſpecies of cup, and the baſe, you ſee, is a kind of phial of the ſame matter as the tube. I now fill this phial with red wine; and then I fill the cup and the tube above it with water, and deſire you will not only tell me your obſervations, but account for them?

GEORGE.

I begin to ſee (if I miſtake not) one of the moſt beautiful of all experiments: I obſerve a delicate film of the wine raiſe itſelf off the ſurface of the phial, form itſelf into a point, direct itſelf in the form of a column to the mouth of the cup, and continue its progreſs through the water; while at the very ſame inſtant of time, an equally ſmall thread of water deſcends from the cup into the phial; and both the column of the wine and the thread of the water continue, the one to mount, and the other to deſcend, in a ſpiral motion, until every drop of the water ſhall have fallen into the phial, and every particle of the wine aſcended into the cup.

The reaſon of all this I ſcarce need mention after what has been already ſaid by my ſiſter Mary. I can only add to her account in this inſtance, that the water being the heavier of the two bodies, and placed in the uppermoſt part of the veſſel, cannot have its exertion of deſcent made otherways known, than by its forcing the wine to appear firſt to move upwards.

LADY CAROLINE.

You alluded, George, to your ſiſter Mary's anſwer; but how will that, or your own anſwer, account for this? the two liquids in the inſtance of your ſiſter Mary's experiment, on their being poured on each other, mixed, but in this caſe no mixture takes place.

GEORGE.

In this veſſel the water poured into the cup gently deſcends upon the wine, not by a manual pouring, but by the ſmalleſt of tubes. It is no otherways admitted but by the ſloweſt deſcent of its own weight, without any velocity acquired from a fall. Hence the viſible tranquillity betwixt the aſcending wine and the deſcending water: they have neither of them motion enough to divide or to embarraſs each other, and of courſe cannot mix.

LADY CAROLINE.

I take this inverted ſiphon, and pour mercury into one arm of it, until it riſe in each arm to one half of a graduation. I now pour this coloured water upon it; and the conſequence is, that when the ſurface of the coloured water is riſen, as you ſee, to the fourteenth graduation, the mercury riſes juſt one graduation higher in one arm than in the other. Account for this, Kitty?

KITTY.

The mercury loaded on one ſide by the column of water, riſes on the other ſide in order to balance the liquid which preſſes it; as ſoon as it ceaſes mounting, its height above its own level is equal to the fourteenth part of that of the water; and I have heard Sir Thomas ſay, that the weight of water is to that of mercury, as 1 is to 14: it is therefore very evident that the heights of theſe two balanced fluids are reciprocally proportionable to their denſities, for as the mercury is fourteen times as heavy as the water, ſo the water is fourteen times as high as the mercury.

LADY CAROLINE.

How does it happen, William, that our bodies never feel the immenſe weight of the air upon them?

WILLIAM.

From the very moment of our birth we are accuſtomed to its preſſure. This preſſure is equal, uniform, continual, and affects the whole extent of our bodies at once; ſo that one part feels no more preſſure than another: now feeling is nothing elſe but a way of judging of our preſent ſituation, when compared to another preceding ſituation: but if our ſituation has never been altered, the ſenſation of the preſſure can never have been interrupted, and therefore is, to ſpeak the truth, no ſenſation at all.

LADY CAROLINE.

I take this glaſs tube, ſtopped at one end, and of about three feet in length; I pour mercury into it; now that the tube is entirely full, I place my finger on its orifice to ſtop it, and after having turned it upſide down, I convey that end which is ſtopped by my finger into a veſſel which likewiſe contains mercury, and I now take away my finger from the orifice. The tube now plunged into the other mercury by the open end, partly empties itſelf, as you may all ſee, into the veſſel; but there ſtill remains a column of mercury of about twenty-ty-ſeven inches in height. Can you explain this, Elizabeth?

ELIZABETH.

The air being a matter or ſubſtance has, like all other bodies, a tendency or weight towards the center of the earth. A heavy body acts by its weight againſt every thing that is oppoſed to its fall, or becomes a baſe to it: thus, when a column of air repoſes upon any body, it compreſſes it with all the ſtrength of its weight. Now the ſurface of the mercury in the other veſſel is, in your experiment, Madam, the baſe of a column of air; it muſt therefore be preſſed by its weight. When your Ladyſhip applied a tube to a ſpot of this preſſed ſurface, the column of mercury the tube contained being heavier than the column of air that immediately correſponds to its baſe, ſinks, until its diminiſhed elevation places its weight in balance with the preſſure exerted on all the ſimilar parts of the ſurface of the mercury in which the tube is plunged.

LADY CAROLINE.

I now make a ſmall aperture in the uppermoſt and cloſed end of the tube, and I perceive that the mercury immediately deſcends. What is the reaſon of this, Henry?

HENRY.

The air by this means enters through the ſmall aperture you made, and acts upon the mercury ſo as to deſtroy the effort that the other part of the air made upon the mercury contained in the veſſel: thus the column of mercury in the tube being placed betwixt two equal preſſures, muſt fall to its own level through its own weight.

LADY CAROLINE.

I take this other tube, Fanny, open at both ends, and placing one end of it in this veſſel full of coloured water; I ſuck up the air which is in the tube, and the water immediately ſucceeds, aſcends and fills it. How do you account for it?

ELIZABETH.

The air being a matter or ſubſtance has, like all other bodies, a tendency or weight towards the center of the earth. A heavy body acts by its weight againſt every thing that is oppoſed to its fall, or becomes a baſe to it: thus, when a column of air repoſes upon any body, it compreſſes it with all the ſtrength of its weight. Now the ſurface of the mercury in the other veſſel is, in your experiment, Madam, the baſe of a column of air; it muſt therefore be preſſed by its weight. When your Ladyſhip applied a tube to a ſpot of this preſſed ſurface, the column of mercury the tube contained being heavier than the column of air that immediately correſponds to its baſe, ſinks, until its diminiſhed elevation places its weight in balance with the preſſure exerted on all the ſimilar parts of the ſurface of the mercury in which the tube is plunged.

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LADY CAROLINE.

I take this other tube, Fanny, open at both ends, and placing one end of it in this veſſel full of coloured water; I ſuck up the air which is in the tube, and the water immediately ſucceeds, aſcends and fills it. How do you account for it?

FANNY.

I ſee no other reaſon for it, Madam, than that the water, unloaded of the weight of the air contained in the tube, obeys the weight of the column of air which preſſes the water in the veſſel.

LADY CAROLINE.

In this other veſſel full of mercury, I dip the end of a tube of at leaſt thirty inches length, but not more than one twelfth of an inch in width. I ſuck the air out from the tube, and the mercury riſes up twenty-ſeven inches, or thereabouts, and though I ſhould continue to ſuck, the mercury will riſe no higher. Can you give me a reaſon for this, Mary?

MARY.

As the mercury is a great deal more heavy than the water, the weight of the external air which helps to raiſe it, is balanced by a leſs long column. Had there been any other fluid more heavy than the mercury, we ſhould have certainly ſeen it remain at a point ſtill lower. In a word, in pumps where ſuckers are employed, the water only mounts to two-and-thirty feet; becauſe as the weight of the atmoſphere is limited, a column of air does not weigh more than a column of water of thirty-two feet, though the column of air be vaſtly higher. Now mercury aſcends only to the height of twenty-ſeven inches; for its weight being to that of the water, as one is to fourteen; the column of air in raiſing up the mercury to twenty-ſeven inches, exerts itſelf as much as it does in raiſing the water to thirty-one, or thirty-two feet. For the mercury weighing fourteen times more than the water, if it is at the height of twenty-ſeven inches, we muſt, in order to compare this elevation to that of the water, reckon twenty-ſeven times fourteen inches, which on calculation you will find to be thirty-one feet and a half.

LADY CAROLINE.

How is it, Edward, that the greater

number

number of long-billed birds, ſuch as herns, ſtorks, woodcocks, as well as almoſt all quadrupeds, ſuch as horſes, cows, ſtags, and others, can when they pleaſe raiſe up water in their ſtomachs?

EDWARD.

All theſe animals may be more properly ſaid to ſuck than to drink, and the act of ſucking is nothing elſe but that of rareſying the internal air by dilating the capacities which contain it, to give room to the preſſure of the atmoſphere. The cheſt in raiſing itſelf, ſomewhat in the way of the opening pannels of a bellows, prepares a new vacuity, to fill which the external air ruſhes in, an act which we call reſpiration; but if the mouth be moiſt with, or full of water, though this laſt fluid were beneath the ſtomach where the void is made, it is thither carried by the weight of the air with which it is always loaded.

LADY CAROLINE.

Why is it ſo very difficult, Sophia, to

draw up the ſucker of a ſyringe, the orifice of which is either entirely ſtopped, or in a veſſel void of air?

SOPHIA.

While the ſucker preſſed externally by a column of air, is likewiſe preſſed back internally by another column of water, ſupported by an inferior column of air, it is in balance betwixt two equal powers; and to move it, we have nothing to do but to get the better of its friction. When, however, the inferior ſupporting column of air is removed, we can no more draw the ſucker upwards, without raiſing the whole column of air that preſſes againſt it: and this column is a cylinder, the height of which is the atmoſphere itſelf, and the baſe the top of the ſucker.

LADY CAROLINE.

Here is a ſmall pair of bellows, Frederic, of which I have ſhut up all the apertures. Take them and tell me what you experience?

FREDERIC.

I experience that it is with a great deal of difficulty that I can move them. They appear to me to be in the ſame ſituation as the ſucker in the ſyringe; for as there is no internal air to act againſt the external air, there can be no balance.

I ſhould imagine that it is for the ſame reaſon that the breaſt of an animal can no longer expand itſelf as uſual in the act of reſpiration, when the admittance of the air is impeded. And it is the opinion of all able anatomiſts, that drowned animals have died, not through the quantity of water they have ſwallowed, but through the interruption of that motion which reſpiration requires.

LADY CAROLINE.

I take this tumbler, George, I fill it with water, and cover it with a paper that will cloſely touch its rim all round. I place my hand upon it, and then turn the glaſs upſide down upon my hand: I now take my hand away, and you notwithſtanding ſee that the water remains unmoved in the tumbler, and the paper adheres as cloſe to it as if the tumbler were placed upright? Is there any reaſon you can give for this?

GEORGE.

The water contained in the tumbler cannot deſcend, but by overpowering the columns of air betwixt it and the floor, and ſupported by the floor; nor can it be removed ſideways, as it is propped on all ſides round by the atmoſphere itſelf, which has a ſtrength of bearing up a maſs of water of thirty-two feet height. Thus the reſiſtance of the column beneath the water in the glaſs is a great deal more than ſufficient to keep it from falling. The uſe of the ſcrap of paper in this experiment is only to hinder the diviſion or mixture of the two fluids; for their weights are ſo very different, that they could not be otherways hindered from falling into each other, if I may uſe the expreſſion.

SIR THOMAS.

I once ſaw, when abroad, Kitty, an experiment of a moſt ſingular nature, which I hope you will be able to account for. A tube of ſome feet length, I forget the number, communicated at one end with about a dozen of other ſmaller tubes. The ends of each of thoſe tubes terminated in as many bladders; in the middle of the large tube there was a kind of key, which could open or ſtop up the paſſage of the tube; this was the apparatus, but the occaſion of this apparatus was the following:

A very conſiderable bet was laid between two young men of the firſt faſhion in Italy, on the reſpective ſtrength of the Swiſs, who guarded their gates. In the altercation, one of theſe noblemen laid the wager alluded to, and ſaid that the ſon of his Swiſs, eight years old only, had more bodily ſtrength than the Swiſs of the other nobleman.

On the day agreed upon, a large beam was placed acroſs the ſmall tubes of the inſtrument I have already mentioned to you. It was then propoſed to the Swiſs to raiſe that beam, and ſimply remove it from the tubes: every exertion of his ſtrength was put forth in vain, he could not ſo much as give it an appearance of motion. The child was then called, and, having received his cue, deſired every body ſhould withdraw to ſome diſtance from the beam, then blew into the tube with all his might, and when tired, turned the key or cock, that the air might not return back, and this he continued for a while to the great amuſement of his maſter's opponent; in a few minutes more, however, he ſo effectually filled the bladders with air, that the beam roſe of its own accord, and rolled with great noiſe from off the tubes.

KITTY.

The breath of the child, I ſhould think, compreſſed and gave a new ſpring to the air contained in the large tube, from which the air in the ſmaller tubes and in the bladders receives a gradual and growing preſſure; this ſucceſſive exceſs of ſpring or elaſticity, exalted by the heat of the child's breath, diſtends the bladders ſo violently, that the impriſoned air, becoming at laſt equal in ſtrength to the weight of the beam, communicates a commencement of motion to it, which the weight of the beam itſelf completes, by adding power enough to the ſpring, through preſſure, to force it at length entirely from its ſituation.

LADY CAROLINE.

Why does a heavy body, William, weigh leſs in the hand of a perſon who holds it in a heavy fluid, than if the ſame perſon held it in a fluid of leſs denſity?

WILLIAM.

All bodies are ſupported in fluids, in the exact proportion of the weight of thoſe fluids. If I take a body that weighs ten pounds in the air, and plunge it into water of an equal volume with itſelf, and which perhaps weighs two pounds, my hand will then have only to ſupport eight pounds weight.

SIR THOMAS.

Do you recollect, Elizabeth, what may be the weight of the column of air which correſponds to the human body?

ELIZABETH.

It has been diſcovered that a middling ſized perſon correſponds to a maſs of air of upwards of twenty thouſand pounds weight. But a fiſh at the bottom of a river or of a lake has not only the preſſure of the air, but that of the water to ſupport; ſo that if it be thirty-two feet deep, it is loaded with twice the weight of the atmoſphere. What then muſt the preſſure be on the body of an animal at the bottom of the ocean? Theſe enormous weights, however, continually applied to the ſurfaces of their bodies, do not deſtroy them, for the reaſon that they are internally ſupported by the ſpring of the ſame fluid which ſurrounds them; we breathe within the ſame air by which we are compreſſed without, and fiſh are in the ſame ſituation as we are with regard to the water; for if they breathe air with water, this air, before it paſſes into their bodies, is in balance by its ſpring with the preſſure of the fluid with which it is charged. The motion of the breaſt, in the time of breathing, is only free in as much as there is an equilibrium betwixt the external and internal air. Whatever accident renders the laſt weaker or ſtronger, adds to the difficulty of reſpiration. In a word, neither the weight of the air, nor that of the water, deſtroys the diver who plunges to the bottom of the ſea, becauſe he is equally preſſed on all ſides round, and becauſe the internal balances the external air, and that his ribs form a ſeries of arches. It muſt be, however, remarked, that many divers who have been ſent down under water in large bells full of air, have generally been obliged to be drawn up, their noſes and ears running with blood. The reaſon of this is, that it is not ſufficient that the diver has air conveyed down with him; it is alſo neceſſary that that air preſerve the uſual thickneſs he was accuſtomed to; and I do not think that this can ever be practicable, conſidering the vaſt preſſure of ſo immenſe a volume of water.

SIR THOMAS.

When fiſhermen have thrown their net to great advantage, how comes it, Henry, that they are not afraid of breaking it when they draw it from the water into the air?

HENRY.

Immerſion always reduces bodies to a reſpective weight, much leſs than their abſolute one. Thus it ſometimes happens, that a man of one hundred and thirty pounds weight on land, is not above one or two pounds in the water. Hence a twig, or even a few blades of graſs on a bank, may ſometimes ſave a drowning perſon, whereas a perſon falling out of a window would pull the weight of a very conſiderable relief after him.

LADY CAROLINE.

I throw this wax ball into a baſon of cold water, and it ſwims. I now heat the water over this chafing-diſh, the ball then ſinks, but now the heat increaſes, and the ball mounts again. Can you give any reaſon for this, Fanny?

FANNY.

It ſwims at firſt becauſe it is leſs heavy than cold water; it then ſinks becauſe it becomes heavier than an equal volume of water rarefied by heat. It afterward mounts again, becauſe being itſelf now rarefied by the ſtill increaſing heat, which penetrates and dilates the air that it contains, it becomes lighter than an equal volume of water.

LADY CAROLINE.

How do fiſh, Mary, remain ſuſpended and motionleſs? How do they go up and down the water with ſuch freedom?

MARY.

They have in their bodies a bladder, which they fill with air when inſtinct prompts them to become more light, and which they empty when they mean to become heavier: theſe viciſſitudes of lightneſs and gravity are aided by the ſtrokes of their tail againſt the reſiſting fluid.

LADY CAROLINE.

Why, Edward, do drowning animals deſcend at firſt to the bottom of the water?

EDWARD.

Becauſe their bodies are heavier than the volume of the water in which they fall.

LADY CAROLINE.

Why do we afterwards ſee the drowned animal on the ſurface of the water? And why are theſe appearances ſometimes ſo very frequent? Tell me, Sophia.

SOPHIA.

It is becauſe their carcaſes become alternately lighter and heavier than the volume of water to which they correſpond; the body deſcends at firſt into the water, becauſe it is heavier; it then re-aſcends, becauſe the dilatation of the internal air gives more volume to the body; it then at laſt re-plunges, by the burſting of the membranes which contained that air, and by means of which the body was made to ſwim.

SIR THOMAS.

How, Frederic, is the act of ſwimming accounted for?

FREDERIC.

The ſwimmer raiſes the water at his ſides by the motion of his arms and legs, the neighbouring columns of water become by this means higher: being thus made longer, they weigh more, ſince all columns of water weigh in proportion to their height. The great quantity of air which the ſwimmer likewiſe inhales, aſſiſts him conſiderably in this exertion by diminiſhing his reſpective weight.

SIR THOMAS.

And pray, Frederic, why do ſwimmers ſometimes uſe bladders under their arms?

FREDERIC.

To increaſe the volume of their body, and thereby procure more columns of water to ſupport them.

SIR THOMAS.

Since we are upon this ſubject, Frederic, I ſhall aſk another queſtion. How does a diver, after touching the very bottom of the ſea, remount?

FREDERIC.

His reſpective weight in ſuch an immenſe body of water is much leſſened; he has nothing to do but to ſtrike the bottom perpendicularly with his foot, to procure a ſpring; the collateral columns of water will then urge him upwards with great velocity.

LADY CAROLINE.

How is it, George, that a large veſſel at ſea ſails with the utmoſt ſecurity, whereas, as I have heard it ſaid, it would ſink on a lake of freſh water?

GEORGE.

Salt water is much more heavy than freſh water, and therefore can ſupport a much greater weight; for it is well known that all floating bodies ſink more or leſs, according to the denſity of the fluid they move in.

LADY CAROLINE.

I have heard much talk of the floating iſlands, Kitty. Can a motion of this nature happen?

KITTY.

I think it may; water may in proceſs of time undermine any mould, and the piece of earth is kept cloſe together by its being of a light nature, and interwoven in its parts by immenſe quantities of roots and other ligatures.

LADY CAROLINE.

Your conception, Kitty, is clear and adequate to the ſubject. How does it happen, Henry, that leſs water is requiſite in order to ſupport a veſſel in a ſtrait, than in the wide and ſpacious ocean?

HENRY.

In the ocean, water expands itſelf into a larger circle, and riſes to a leſſer height. In a more confined place, water correſponds to a leſs width, and riſes to a greater altitude. Now, water having a great weight, counterbalances and ſupports the ſhip preciſely in the proportion of its exaltation: hence, the more a harbour is narrow, the leſs need is there of depth of water.

LADY CAROLINE.

Why, William, do fluids aſcend in capillary tubes?

WILLIAM.

The unequal preſſure of whatever fluid is probably the fundamental point of the explanation of the aſcenſion of the fluids in capillary tubes; but the adherence or natural viſcoſity of all liquors, the ſize and the figure of their parts, and perhaps a certain motion which belongs to them, are ſo many means which nature may have employed for theſe kinds of effects, and as ſo many objects which we ought to conſider in our reſearches.

Here Sir Thomas interrupted William, ſaying, that capillary tubes are ſo called on account of their minuteneſs. They may be made of glaſs, or any other matter fit for containing water. They take this name, without doubt, from the reſemblance that their apertures have to a hair, which we commonly look on as ſmall canals, hollow throughout the whole length, and capable of tranſmitting ſome certain ſpecies of fluids. However, the diameter of capillary tubes may be equal to two twelfths of an inch, and even two twelfths and a half of an inch.

LADY CAROLINE.

We often find a heap of ſand, a ſoft ſtone, a billet placed upright, moiſtened even to the top, although theſe bodies may not be an inch in water. What is the cauſe of this, Frederic?

FREDERIC.

As theſe bodies are porous, the water finds in them minute channels through which it aſcends, as it would do in ſmall tubes of glaſs; and to improve ſtill farther this idea, becauſe in a channel extremely poliſhed and very ſtrait, the liquor oppoſing all its weight to the cauſe which elevates it, in lieu of paſſing through the winding paſſages, which are offered to it by the internal part of a ſolid body, it finds here and there a reſting place: whence it may happen that it ſets off by repeated ſprings, and perhaps with freſh force.

LADY CAROLINE.

Why, Mary, do the waters, and in general all bodies, evaporate a great deal leſs in moiſt and calm weather than when it blows a dry wind?

MARY.

Becauſe a capillary tube which ſupports a column of liquor, like a ſpunge full of water, cannot draw up any more; in the ſame manner the air being too much loaded, raiſes vapours no longer. In moiſt weather the air is a charged ſpunge; in a dry wind it is an empty ſpunge, and which is conſtantly renovated upon the ſame ſurfaces.

LADY CAROLINE.

What is it, my dear Fanny, that makes the vapours fall in rain?

FANNY.

It is a degree of cold which condenſes the part of the atmoſphere where thoſe vapours reign, and which drawing together the particles of water, unites them into drops too heavy to be ſupported by an equal volume of air; then the condenſed air is a ſpunge compreſſible. This compreſſion may be attributed not only to the chilneſs which may be the uſual cauſe, but likewiſe to the winds, by which the clouds are ſqueezed together, that is, the parts of the air moſt loaded with water; and in fact, the rain, particularly that of a ſtorm, always falls by ſudden guſhes, like the expreſſion of a ſpongious body full of water.

LADY CAROLINE.

How, Edward, does the ſap of a tree paſs from the roots to the trunk, and from the trunk to the branches?

EDWARD.

We may look on its courſe as on ſo many ſmall capillary channels, or as a continuity of ſpongious bodies, by which it is conveyed from the roots to the top of the tree, and more or leſs copiouſly, according to the actual ſtate of the different parts which receive the ſap.

LADY CAROLINE.

How, George, does every tree in a garden receive the nutriment which nature has prepared for it? How can the apple-tree not take that which is adapted to the vine, to the myrtle, to the jaſſmine, and to the honey-ſuckle?

GEORGE.

If it be true, that the channels which convey the ſap perform the office of capillary tubes, there preſents itſelf an example of this kind, which might be looked upon as a coarſe imitation of nature concerning the object before us. If we put into a vaſe two liquors very different each from the other, as oil and wine, and if you dip the two ends of a piece of liſt, one into the wine, the other into the oil, of which one will imbibe wine, and the other oil, both will act like a ſponge; but the firſt will ſuck up the wine alone, and the laſt only the oil. All bodies of this kind are fit for drawing up fluids, but they load themſelves with one rather than another, according to the analogy it has with thoſe liquors. This analogy muſt undoubtedly conſiſt in the form, the ſize, the diſpoſition of parts, &c. Each ſpecies of plant probably does ſomething of the like nature, and for the ſame reaſons.

LADY CAROLINE.

You have anſwered, my dear ſon, like a lad of genius and penetration. I ſhall elucidate this in another place; however, my dear George, I muſt remind you of a remark which you forgot to mention, that the ends of the liſt ſhould, previouſly to their being put into the oil and wine, be daubed, one with oil and the other end with wine, or otherways they might both at once abſorb the oil, and leave the wine untouched. Why, Kitty, does an angular or pointed body wound us more in falling upon us than a flat body?

KITTY.

Becauſe its effort is wholly exerted upon one ſmall ſpot, and by a contrary reaſon we riſk leſs being hurt when we hold our hand hollow to receive a bowl than when we extend it.

LADY CAROLINE.

I ſuppoſe that there is a great deal more ſubtle air within one body than in another; the conſequence will be, that this laſt body will be leſs hard. What is the reaſon of this, Henry?

HENRY.

Becauſe then the ſolid parts of which it conſiſts touch each other by leſs ſurfaces, and the preſſure from without is better ſupported by that which the fluid tranſmits inwardly. When wax, for inſtance, ſenſibly ſoftens, it is that the ſubtle air with which it is penetrated, dilated by the heat, dilates in the ſame manner the ſpace that it occupies; and as theſe ſpaces cannot increaſe but by removing the ſolid parts of thoſe which ſurround them, the contact of theſe laſt becomes more rarefied, their junction leſs exact, and their coherence leſs ſtrong.

LADY CAROLINE.

In ſome determinate caſes, two liquors take all on a ſudden a conſiſtency greater or leſs, although we are not able to obſerve any degree of ſenſible refrigeration. Pray tell me if you underſtand this, William?

WILLIAM.

This effect I have heard Sir Thomas call *coagulation*, and it can be explained by ſuppoſing that the parts are of different configurations, and ſuch as to reciprocally embarraſs each other; and that they put an end between themſelves to that mobility, in which principally conſiſts the ſtate of being liquid. The moſt beautiful coagulation is that which is made with oil of lime and the oil of tartar. When a perſon ſtirs this mixture a little, it becomes a white maſs, to which you may give any form you pleaſe, hardening itſelf like wax.

Some people, likewiſe, coagulate a urinous, volatile, and a very ſubtile ſpirit, with the ſpirit of well-rectified wine; the white of an egg and the ſpirit of ſalt; blood and aqua vitæ, or brandy.

This laſt experiment informs us of what importance it is ſoberly to uſe ſpirituous liquors, ſince they have the power of adulterating and ſtopping the fluidity of the blood.

LADY CAROLINE.

A ſpecies of long clear glaſs bottle is filled with water, and if you would preſerve it from freezing during the winter, you put in one third of ſpirits of wine; then cloſe the mouth of the bottle by tying a moiſtened piece of bladder round the neck. In this bottle there is a little hollow and enamelled figure, or figures, ſuch as men or birds, which are more light than the liquid they ſwim in; and in the foot of which figures, a little hole is made through which a pin may paſs. The effects of this invention now follow:

In the firſt place, with the extremity of your finger you preſs upon the bladder; the figure deſcends to the bottom of the bottle, and is there ſtopped, and remains there as long as the preſſure continues.

In the ſecond place, if you preſs with leſs force, or if you ceaſe to preſs, it immediately riſes.

In the third place, if you moderate the preſſure, when the figure is on its way of deſcending, it ſtops at the very ſpot in which you chooſe to keep it.

In the fourth place, if you preſs the bladder, and at the ſame time whirl the glaſs around, the little figure plays the whirligig about its own axis.

Theſe effects are the ſame when you turn the bottle upſide down, and when that preſſure is made from the lower part to the higher; thus, one may give it an air of myſtery, by arranging many tubes in a frame, and making the neceſſary preſſure on their orifices, in a manner hidden from the eyes of the ſpectators, with levers ſending them back, or with ſtrings hidden in the depth of the wood, or otherways. Can you, Elizabeth, explain theſe effects?

ELIZABETH.

In the glaſs parallelogram in the ſummer-houſe, theſe effects are all produced, and it is upon this that your Ladyſhip has been ſpeaking; previous to my anſwering your queſtion, I will run for it.

The water is either not compreſſed, or is compreſſed with great difficulty. The air, on the contrary, is a flexible fluid, which may be compreſſed with the greateſt facility. The little hollow enamelled figures which are here incloſed, are therefore full of a compreſſible matter, and environed with another that is not. When you preſs with your finger upon the bladder, as I now do, I preſs all the maſs of water which is in the bottle; the column which correſponds to the ſmall hole in the figure, which your Ladyſhip has mentioned, not being able to re-enter upon itſelf, on account of its inflexibility, carries all the effort that it receives from the preſſure againſt the air which is in the figure: and as this fluid allows itſelf to be compreſſed and ſqueezed into a ſmaller ſpace, it yields to the water a part of that which it occupies; then the figure is more weighty than it was, for we muſt look upon it as a compoſition of enamel; of air more condenſed; and of a little water which it has received. If the whole, all together, be more heavy than the correſpondent volume of water, it goes to the bottom; it, on the contrary, re-aſcends when it is lighter, that is, when a leſſer preſſure impels leſs water into the figure, or when I ſhall allow the compreſſed air the liberty of repelling, by its ſpring, that which has already entered; and you may very readily conceive, that by managing this preſſure of the finger, I retain in the figure ſuch a quantity of water, that the whole, all together, is in equilibrium in the maſs. At laſt, as the little hole through which the water may enter or flow out, is made one of the two legs; that is, on the ſide of this little plunged body: if the fluid which paſſes into it be puſhed, or repelled with a violent velocity, the oblique impreſſion makes the figure turn round itſelf; for being thus ſuſpended in the water, it is as if it were moveable upon two pivots, or upon an axis. This figure, or figures, become ſometimes more light, ſometimes more heavy, than the liquid in which they are plunged; not that the volume of the correſpondent water changes its denſity or its ſize, but becauſe the plunged bodies become themſelves alternately more denſe and more light, in matter, without changing their volumes.

If you recollect, Madam, we once ſaw in our town here, a quack, who ſucceeded in a wonderful manner in theſe experiments; he called this figure his Little Devil, and made it aſcend, ſometimes to prove the goodneſs and efficacy of his remedies, and ſometimes to thank the buyers, with various other tricks and devices.

LADY CAROLINE.

Your explanations and remarks upon this ſubject, my dear Elizabeth, have been clear and ſenſible. Tell me, Fanny, how a great number of animals, and above all quadrupeds, can have more facility in ſwimming than men?

FANNY.

When a quadruped ſwims, it can hold its head out of the water without much effort; but of man, the head is the firſt part of his body which plunges; and even when he ſwims well enough not to go to the bottom, he is ſtill under the neceſſity of making the utmoſt efforts to avoid having his face in the water: thus it is, that a ſwimmer is much more at eaſe upon his back than in any other ſituation.

LADY CAROLINE.

Why do birds, being heavier than an

equal volume of air, fly? Tell me, Sophia.

SOPHIA.

When birds fly, the cheſt is dilated by a greater quantity of air than enters to it; they extend their wings, their tail, increaſe their volume, and conſequently diminiſh their reſpective gravity. The air, ſtruck by their wings, becomes a fixed point, by which they procure motion to aſcend, to deſcend, or to advance.

LADY CAROLINE.

Why does a ſtone bridge, loaded with men, animals, &c. which, inſtead of pillars, has nothing but moveable barges, ſtill ſupport itſelf?

MARY.

Becauſe the volume of ſtones and of air contained in theſe barges are more light, on account of the ſmall weight of the air, than an equal volume of water.

LADY CAROLINE.

Why, Frederic, does a ſteel needle, placed ſoftly and gently upon the ſurface of a tumbler of water, ſwim by itſelf, without falling immediately to the bottom of the glaſs.

FREDERIC.

The lightneſs of the air, the form of the tumbler, with the viſcoſity of the water, produce this effect. The air clings to the needle more eaſily than to the water, for it is with difficulty that the needle can be moiſtened; the water flows even above it, without being able to wet it. This ſuppoſed; on the viſcid ſurface of the water, which makes the parts more difficult for ſeparation, the weight of the needle, with the air environing and ſurrounding it, produces a kind of cavity, in which the needle appears to lie beneath the ſurface of the water. It is in this way, that this little volume, compounded of the needle and the air, is more light than an equal volume of water, and therefore it muſt ſwim above the ſurface of the water. In a word, we may moiſten the needle, and, the particles of air no longer adhering to it, it will inſtantly go to the bottom.

LADY CAROLINE.

You have anſwered, my dear boy, with great good ſenſe; and I ſhall now leave this ſubject, thanking all of you, my good children, for your attention and rational anſwers to the queſtions which I have propoſed to you.

Here Sir Thomas, previous to their withdrawing, informed them that he had forgotten an eſſential part of the exerciſes in queſtion, which was, to put into their hands a Table of the relative weights of bodies of the ſame volume to each other. "I beg," ſaid he, "that you will all of you commit it immediately to memory, as it will clear up many things which have been already mentioned, and help you the more eaſily to underſtand thoſe which are to follow.

TABLE

Of the Weights of different Bodies, according to the beſt Calculation.

	Cubic Foot.		
Gold	1326	-	4 Ounces.
Mercury	946	-	10
Lead	803	-	2
Silver	720	-	12
Copper	558	-	0
Tin	516	-	2
White Marble	188	-	12
Slate	150	-	0
Brick	127	-	0
Lime	85	-	2
Sea Water	70	-	10
River Water	69	-	12
Wine	68	-	6
Wax	66	-	4
Oil	64	-	0

THE FOURTH CONFERENCE.

ON AIR, MUSICAL AND COMMON SOUNDS, AND WIND.

SIR THOMAS.

I AM now, my dear children, about to ſpeak of Air, and ſeveral things appertaining to it. This ſubject will be entertaining and inſtructive; you will find pleaſure in every elucidation that will here take place; ſo be attentive, I requeſt you, while I communicate the following preliminary obſervations:

1ſt. Air is a fluid which covers the ſurface of the earth, and which encompaſſes it on all ſides round. It is the moſt univerſal element, and the moſt neceſſary for the preſervation of every thing that lives on the earth. It is the air that forms the winds, that makes the waters evaporate, that beſtows vegetation upon plants, that ſupports the life of man, and of all animals. It is the vehicle of ſounds, odours, &c. &c.

2d. Air is a ſubſtance of which the nature is fixed, of which the integral parts are ſimple and homogeneous, and the principles united in ſuch a manner as never to give way to any efforts that we might be able to make to diſcompoſe it.

3d. It is probable that air remains conſtantly fluid, becauſe it is perfectly elaſtic; if it were only compreſſible, its parts brought together might perhaps touch each other near enough to form a hard body, and nothing could force them to depart from that ſituation; but the ſpring which they have naturally tends to rarefy the maſs of which they are compounded, becauſe the ſtrongeſt compreſſion will be vainly uſed to force it; thus theſe parts preſerve that reſpective mobility in which fluidity conſiſts.

4th. We may conceive of the integral parts of the air as of minute filaments, outlined in the form of ſpiral lines, or of ſcrews, flexible and elaſtic, and their aſſemblage nearly like a little packet of cotton, or of carded wool, which you may eaſily reduce into a very ſmall volume, when you preſs it; but which, when compreſſion ceaſes, always riſes and ſpreads itſelf, regaining its firſt ſituation.

5th. Air, like all other fluids, weighs in every direction. Its ſpecific gravity, although not always the ſame, is to that of water, as 1 i to 606, and thence up to 1000.

6th. The void, which is generally made in the recipient of an air-pump, is not, properly ſpeaking, a void; it is only rarefied air. But obſerve, that the air which re-enters again into the void, out of the recipient, may, as people have computed it, run in a ſecond of time the ſpace of 1305 feet; while a wind, which in a ſecond of time paſſes through 32 feet, is a hurricane capable of tearing up trees by the roots.

In order to aſſiſt your underſtandings on this ſubject, my dears, one of you run to my library; you will there find the Literary Journal for the year 1716; in the ſecond part of which, page 260, an explanation will be found of what we have been alluding to.

7th. We muſt ſuppoſe that the parts of air, intimately mixed with any other matter, do not any longer touch each other; but that they are immediately applied to the very parts of the body which contains them, as ſmall hairs might be, or the filaments of cotton, which might envelop, for inſtance, minute grains of ſand, or might be ſeparately lodged in the intervals about to be filled between theſe ſame grains, and which then joined together form one maſs. Although a great number of filaments of cotton uſually form a ſmall flexible flake, which occupies a ſpace conſiderably ſenſible, on account of all the vacuums which are in its volume, we yet perceive that it would occupy conſiderably fewer of thoſe vacuums with its own matter, if theſe vacuities, filled with another ſubſtance, did not contribute to its bulk.

8th. The atmoſphere is about ſixty miles high, and the vapours or exhalations, being more or leſs abundant, make it more or leſs heavy. The air with which it is compounded is ſometimes very unwholeſome; that is, not in itſelf unwholeſome, but from the different exhalations which mix with it.

9th. The origin of ſound is commonly found in the colliſion or ſhock of two bodies; the ſhaken parts of which produce a tremulation and ſound on all ſides to a certain diſtance, ſtriking the fluids that ſurround them.

This tremulation is communicated to other bodies which are ſuſceptible of receiving it; that is, which meet in the ſphere of its activity. Sonorous bodies, properly ſo called, are thoſe of which the ſounds, after the ſhock or friction ceaſes that produced them, are diſtinct, comparable with each other, and of ſome duration; for we muſt not give this name to thoſe bodies, the fall or ſhaking of which occaſions a confuſed and ſudden noiſe, ſuch as the diſcharge of a cart of gravel, for inſtance, the noiſe of a water-fall, or the roaring of agitated billows. None but elaſtic bodies are really ſonorous; and the ſound they give is always in proportion to their vibrations, either in reſpect to their duration, or of the intenſeneſs and force of their ſound.

10th. In the rope as well as the bell, when we pull it for a ſound, we may perceive two kinds of vibrations: the firſt *total*, becauſe they belong entirely to the ſonorous body; I mean thoſe vibrations which proceed from the zones of an oval clock, or rather thoſe which were circular before they were changed into ovals, by which we may ſee the ſtring of a violin or a harpſichord under the figure of a parallelogram. The other vibrations, which we may call *particular*, belong to the inſenſible

ſenſible parts, and may be looked upon as the elements of the firſt vibrations.

People formerly believed that bodies were ſonorous by the *total* vibrations; but they are now undeceived, and fully convinced of their error. It is principally to three foreigners that we owe this correction. The laſt of the three, whoſe name was *De la Hire*, was the chief corrector of this falſe ſuppoſition: he proved by a very judicious experiment, that ſound eſſentially conſiſted in the *particular* vibrations of the inſenſible parts. * "Let a perſon," ſaid he, "hold "a pair of tongs ſuſpended upon his finger, "and let him preſs with the other hand the "two arms, and afterwards allow them to "eſcape, they begin their vibrations, but "they remain mute. Inſtead of reducing "them into practice in this manner, the "perſon muſt ſtrike one of the arms with "his finger, or with any other ſolid body,

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* See Memoirs of the Academy, 1716, p. 269.

" and though they will ſtill make vibra-" tions as they did in the firſt trial, yet the " perſon who tries the experiment will " have the pleaſure of hearing the vibra-" tion accompanied by a very intelligent " ſound." Now, what can be more exactly in point with this poſition, than the tremulation of the parts of the iron which a perſon might feel if he gently conveyed his hand to it? It is therefore to the parts which tremulate, that ſound muſt be attributed; and after this experience we ſhould be perſuaded, that were it poſſible to ſeparate theſe two ſpecies of vibrations, we ſhould never have any ſound with thoſe we call total: but when the laſt ariſe from the firſt, and this is the moſt uſual caſe, although they make not the ſounds by themſelves, they regulate the force, the duration, and the modification of them.

11th. The air tranſmitting ſound ought to have a certain denſity, that its parts may act ſtrongly enough and freely each on the other. It ſhould be elaſtic, becauſe the movement of the vibration originates in the ſpring of the parts.

12th. Sound runs through 173 fathoms, which are 1038 feet, in a ſecond by day or by night, in ſerene or boiſterous weather. The motion of light has therefore no connection with the propagation of ſound, the mingled vapours with the particles of air do not interrupt the motion of vibration. If it blow a wind, of which the direction be perpendicular to that of ſound, this has the ſame velocity as it has in calm weather. If the wind blow in the ſame line, traverſed by the ſound, it retards or accelerates according to its own velocity; I mean, that, with a favourable wind, ſound will ſurpaſs by 173 fathoms in every ſecond the velocity of the wind; on the contrary, if the wind be directly oppoſed, the velocity of the ſound is ſtill uniform; that is, in equal and continuous times, it will always traverſe a like ſpace. The intenſeneſs or force changes nothing in the velocity of ſound. Although a ſtrong ſound extend itſelf farther than a weaker, yet the latter, as well as the former, goes through 173 fathoms every ſecond.

13th. We muſt believe that the particles of air, differing infinitely in ſize, differ alſo in their degrees of ſpring, as a blade of ſteel would make the ſprings more ſtiff of both, if it be divided into unequal portions. Place a ſonorous body wherever you will, it muſt find in the common maſs particles of air, of which the ſpring is analogous to its own, and which will conſequently be capable of receiving, of preſerving, and of tranſmitting vibrations. Thus, two cords of different tones make themſelves heard through the ſame maſs of air, but by different parts of that maſs. It is true that a ſonorous body acts firſt on all the particles of air which immediately ſurround it; but it does not effectually continue its action except on thoſe that are fitted to move preciſely like it.

Thus, my dear children, have I endeavoured to open your underſtandings, that you may clearly comprehend thoſe general principles which will enable you to ſatisfy the inquiries of Lady Caroline, by appoſite and rational anſwers, in the moſt eſſential parts of the preſent Conference.

LADY CAROLINE.

Why, in many inſtances, my dear little Mary, does the air communicate humidity to the bodies which it touches?

MARY.

The reaſon I think is, that it communicates to them ſome of thoſe aqueous particles with which it is itſelf more or leſs impregnated.

LADY CAROLINE.

Your anſwer, my good child, convinces me that the preliminary notions which Sir Thomas endeavoured to inculcate, were not loſt upon you. Your alluſion is very juſt to the natural humidity of the air, which, were it not for the ſun, would actually keep us in perpetual damps. Now tell me, my dear, how the air dries linen?

MARY.

I ſhould imagine that, congenial to the nature of the ſponge, it imbibes the watry particles contained in the linen.

LADY CAROLINE.

What is the reaſon that cordage and ſails which have been ſteeped in ſea-water, are dried in the air with ſo much difficulty?

MARY.

I ſhould think that the water, ſtubbornly adhering to the ſaline parts attached to the ſuperficies, the air from this reſiſtance takes a long time to imbibe it.

LADY CAROLINE.

Whence comes it, Henry, that a barometer which has not been filled before the fire; that is, of which the mercury has not boiled in the tube, appears without the brightneſs it ought to have? And whence come all thoſe little bubbles which we perceive in many of thoſe inſtruments?

HENRY.

Sir Thomas has already given me to underſtand, that when we pour out into a vaſe, any liquid which forces the air to ruſh out, there always remains a layer of this fluid or air adhering to the ſides of the vaſe. It is not commonly obſerved, becauſe it is very minute and tranſparent; but it becomes perceivable by the eye, when it is dilated by the vaſe being ſtrongly heated, or when it is placed in the open air.

As for the bubbles, they are produced in the ſame manner; for the ſurface of the inſide of the tube is obſcured with the remaining particles of air, they being in reality nothing more than the mercury intermixed with theſe particles of air.

LADY CAROLINE.

A volume of air of two or three pints,

taken at hazard in the atmoſphere, renders an ounce of ſalt of tartar humid and more heavy than common tartar. What is the cauſe of this, George?

GEORGE.

This ariſes from the ſalt being imbibed by the aqueous particles with which the air is charged.

LADY CAROLINE.

When we begin to empty an air-pump, its ſucker at once deſcends without any obſtruction. How is this effected, Kitty?

KITTY.

It is effected by the dilatation of the internal air, which deſcends into the pump, and puſhes the ſucker down with a force almoſt equal to the reſiſtance of the external air.

LADY CAROLINE.

Why does the ſucker, William, reſiſt ſtill more in proportion as we pump the internal air from the recipient?

WILLIAM.

WILLIAM.

The more internal air we pump out, the more freedom of ſpace has that air which remains, and is greatly dilated; but as the more it is dilated, the leſs ſtrength has it to ſecond the hand, we feel more ſenſibly the reſiſtance of the external air, and conſequently the ſucker appears to reſiſt a great deal more.

LADY CAROLINE.

How does it happen, Elizabeth, that leaving the ſucker free on its deſcent, it reaſcends of its own accord?

ELIZABETH.

The ſucker being repelled by the external air, finds not in the rarefied air of the recipient a reſiſtance equal to the force which repels it.

LADY CAROLINE.

By allowing the exterior air to enter into the recipient, by turning the key and the tube of communication, the recipient comes off. Give me, Fanny, the reaſon of this?

FANNY.

The return of the air puſhes it back to the exact height of it, with an elaſtic force, equal to the action of the gravity of the external air which had puſhed it down.

LADY CAROLINE.

By drawing up again the ſucker, we ſee a kind of ſmoke, a ſmall rain, and the ſides of the recipient ſullied and obſcured from within. What is the cauſe of this effect, Edward?

EDWARD.

The internal air which is rarefied in an inſtant, puſhes and ſhakes the imperceptible vapours which it contains, and which it can no more ſupport, if it be in a certain degree of rarefaction. Theſe vapours, reunited in the concuſſion, and in their fall, pour down rain. The air which is dilated at the ſame time, and with vaſt rapidity, briſkly darts on all ſides round a great number of particles of water, which thrown with the vapours on the ſides of the recipient, ſully it within, and darken it by ſhutting up the paſſages of light. This happens after it has been placed in a moiſtened ſkin, which is extended on the platen.

LADY CAROLINE.

The hand becomes cloſely attached to a ſmall recipient open at the top, when we make a void by the air-pump: this does not take place before the void be made. How does this come to paſs, Sophia?

SOPHIA.

So long as the recipient is full of air, as denſe as that of the atmoſphere, the hand of a perſon is not only preſſed upon its brim, but, beſides, upon the maſs of the fluid which is there ſhut up, and reſiſts the external preſſure: but when the recipient is void, the hand, always preſſed by the air without, is no more ſupported but by the rim of the recipient; and to ſeparate it from it, it were neceſſary to make from the earth upwards, an effort capable of raiſing the column of air which weighs upon the hand. Now, the weight of this column is equal to that of a cylinder of mercury which ſhould have for its baſe the plane terminated by the borders of the recipient, from twenty-ſeven to twenty-eight inches height. It follows thence, that this preſſure is ſo much the more great and violent, as the recipient has more overture upwards; therefore the hand ſticks to it much more than does the extremity of a finger, when a perſon places it upon the very hole which is in the center of the platen; and by the ſame reaſon, a key drilled, when ſucked by any perſon, and afterwards attached to the tongue or to the lip, cannot be detached from either but with the greater difficulty, as the channel of the key is more wide.

LADY CAROLINE.

This external preſſure of the air, which proceeds from its weight, does not craſh the bells of glaſs with which we cover the platen of the air-pump to make the void. Can you, Frederic, give the reaſon for this?

FREDERIC.

Theſe veſſels being always made round, in the form of a cylinder or of a vault, their external ſurface is neceſſarily greater than that within. All the parts which compoſe the thickneſs, reſemble thoſe with which arches are made; they are likewiſe ſimilar to wedges, or to truncated pyramids which mutually ſupport each other, in proportion as they are preſſed towards an axis or common center, by the action of a fluid which weighs in all directions.

What very well proves that the circular form defends the glaſs globes againſt the weight of the air, when they are void, is, that they infallibly fly to pieces when they have any other figure; and thus it happens to two ſides of a bottle which is ſquare, each ſide is puſhed towards the other by two columns of air, a ſtrength which they cannot reſiſt, unleſs they be ſupported by an interior force, equal to that which impels them. Now they are not ſupported by the pumped air of the ſquare bottle, the parts of which, not being diſpoſed in the form of a vault, do not lean on each other, conſequently cannot give mutual aſſiſtance.

LADY CAROLINE.

Why do bottles of thin glaſs, flat on both ſides, and uſually covered with oſier twigs, very often burſt, when carried up to the mouth half full of liquor in order to drink? Tell me, Henry.

HENRY.

It is becauſe the ſuction rarefies the internal air, and the weight of the atmoſphere, acting on the two flat ſides, bears them one againſt the other, and cracks the glaſs.

LADY CAROLINE.

Whence proceeds the great noiſe that accompanies theſe kinds of caſualties, which always by the ſuddenneſs of their report at the firſt inſtant make people ſtart? Tell me, George.

GEORGE.

This effect reſults from the circumſtance of the air entering with great velocity (for we have read before, that the air of the atmoſphere re-entering into the void, flies with a velocity that will make it traverſe 1305 feet in a ſecond); the air, I ſay, enters with great velocity, and all at once in great volume, in a void veſſel of which it ſtrikes the ſides; for the noiſe primitively comes from the ſhock of the bodies, and fluids are very capable of claſhing againſt ſolids.

LADY CAROLINE.

Whence reſults the noiſe that we hear, when we rapidly pull off the top of a toothpick, or pin-caſe? Tell me, Kitty.

KITTY.

It is that then we make a kind of void

which the air from without haſtens to fill, as ſoon as the acceſs is free to it. For during the time that we open the caſe, its capacity increaſes, and the internal air in it becomes ſo much the more rare as it is contained in a larger ſpace.

LADY CAROLINE.

The air that we breathe in a valley is more denſe than that which we inhale on a mountain. How does this happen, William?

WILLIAM.

The air is compreſſed into itſelf by its own weight in the valley; and that of a mountain is charged with a column of leſs length than that of the valley, it muſt therefore be compreſſed a great deal leſs, and of courſe be not ſo denſe?

LADY CAROLINE.

We fix on the platen of an air-pump a little mill, which we cover with a ſmall recipient having a hole in its ſide, and furniſhed with a ſmall end of a tube, which is kept corked while we rarefy the air with one blow only of the ſucker. As ſoon as we take out the cork to leave the channel open, we hear a blowing, and ſee the ſmall wind-mill turn with great velocity. What is the cauſe of this, Elizabeth ?

ELIZABETH.

I imagine that we ſhould attribute this blowing to the air which paſſes rapidly from without to the inſide of the recipient, to re-place that which we have pumped out.

LADY CAROLINE.

Why, Henry, do we ſee two hemiſpheres, from which we have pumped the air, attach themſelves ſtrongly to each other, yet eaſily ſeparated when air has been reſtored ?

HENRY.

When the internal air of the two hemiſpheres is rarefied by the action of the pump, the force of its ſpring is by that means more weakened, the equilibrium is broken, and the adherence of the two hemiſpheres is proportional to the difference which there is between the denſity of the air that externally reſiſts, and that of the air which reſiſts within; ſo that if this one could be reduced to a cypher, it were neceſſary to employ, in order to ſeparate theſe two pieces, an effort ſomewhat greater than the weight of a whole column of the atmoſphere, of which the baſe ſhall have ſix inches diameter; this would produce 400 pounds weight, by only ſuppoſing, according to the common calculation, that a column of the atmoſphere makes a preſſure of ten or eleven pounds weight above a circular ſpace of one inch diameter. At laſt, when the air reſumes its place in the hemiſpheres, they eaſily ſeparate, becauſe the effort that the internal air makes to extend itſelf, and to remove theſe two circular cavities which oppoſed it, is preciſely equal to that of the atmoſphere which externally preſſes them, and each of them is in equilibrium between two powers of the ſame value.

LADY CAROLINE.

Whence comes it, that when we place under the recipient the two hemiſpheres ſtrongly united together, we cannot ſeparate them, not even by the means of a bar of iron, well flattened and edged at the end, which we have paſſed betwixt greaſed ſkins; for, after this, one would imagine that their diſunion would be eaſily effected, becauſe the recipient, though nobody may have pumped the air out of it, ought to hinder above the hemiſpheres the action of the atmoſphere. Whence, Fanny, I aſk, does the cauſe of this proceed?

FANNY.

When we place the vacant hemiſpheres under a recipient, which takes from them all communication with the atmoſphere, it is no more the weight of this atmoſphere which reſtrains the two hemiſpheres, and keeps one againſt the other; but it is the re-action of the maſs of air, previouſly compreſſed by this weight, which is capable of the ſame effects. It is for this reaſon that the two pieces cannot eaſily ſeparate, till we have relaxed the ſpring of the ſurrounding air, by diminiſhing its denſity through many blows of the ſucker, and it is thereby become as much rarefied as that which remains in the two hemiſpheres.

LADY CAROLINE.

The two hemiſpheres placed in the recipient from which we have eaſily pumped the air for their ſeparation, cleave again to each other, when we give once more to the recipient which contains them, the air which we had taken from it. Tell me the reaſon of this, Mary?

MARY.

The air of the hemiſpheres and that of the recipient being rarefied, the forces are equal; they ought then to ſeparate very eaſily, when they are drawn from each other; but if the air, re-entering into the recipient, find the two hemiſpheres rejoined in ſuch a manner that it cannot introduce and extend itſelf, as it has done in the reſt of the veſſel, it preſſes them anew, one againſt the other, on the ſame principle that they had been at firſt attached, and with as much force, if there be the ſame difference betwixt the air without and that within.

LADY CAROLINE.

How does it happen, Edward, that when a vacuity is made, the recipient is ſtrongly united to the platen?

EDWARD.

It happens by pulling down the ſucker from one end to the other of the pump; we thereby produce a ſpace without air, in which that of the recipient fails not to extend, in virtue of its elaſticity; but a maſs of air which divides itſelf into two ſpaces, neceſſarily becomes more rarefied than either of the two; and conſequently, being no longer in equilibrium with the air of the atmoſphere, this laſt muſt weigh a great deal more upon the recipient, and unite it to the platen with ſo much the more ſtrength, as the internal air is more rarefied.

LADY CAROLINE.

Why, Sophia, when a bladder is placed under the recipient, with a ſmall portion of air in it, does it ſwell to ſuch a large ſize?

SOPHIA.

It ſwells by the rarefying of the ſmall portion of air contained in it, in proportion to the loſs of the denſity of that which ſurrounds it.

LADY CAROLINE.

Why, in a ſimilar caſe, does not a body of lead weighing twelve or fifteen pounds weight, hinder the bladder from ſwelling? Tell me, Frederic.

FREDERIC.

It cannot ſwell, becauſe it would not be equivalent to the preſſure of the air which ceaſes to act around in the recipient.

LADY CAROLINE.

A bottle of thin glaſs, and full of air, corked, burſts in the void or recipient. Give me a reaſon for this, George.

GEORGE.

There is nothing to make an equilibrium to the ſpring of the air that the bottle contains, and which makes a continual effort to diſcharge itſelf.

LADY CAROLINE.

Can you, Kitty, account for an egg placed in a goblet emptying itſelf by a hole made with a needle in its under part, when the air is rarefied around it?

KITTY.

An egg, particularly if it be an old one, contains air which ſwims above in the moſt elevated part of the ſhell, on account of its lightneſs; this air extends itſelf and chaſes before it the contents of the egg, in proportion as we diminiſh the preſſure of the external air, with which it was at firſt in equilibrium.

LADY CAROLINE.

How does the egg, William, fill itſelf

again by the ſame little hole, when the air is allowed to re-enter the recipient?

WILLIAM.

We have no ſooner given air to the recipient, than its preſſure makes the matter of the egg re-enter, and ſqueezes the internal air into the ſpace that it firſt occupied.

The following explanation, Madam, I preſume, you will think obvious: if in a phial full of water, of which we plunge the orifice in a veſſel of any ſort, a bubble of air is let in, it cannot fail to occupy the ſuperior part; and if you tranſmit the whole into the recipient, in proportion to the rarefied air within it, we muſt rarefy that air. We ſee that the bubble extends itſelf more and more, and precipitates the water which is ſhut up with it; after which, if the air re-enter the recipient, the liquor re-aſcends, and the air reſumes its firſt volume above it.

LADY CAROLINE.

My good and ſenſible boy, your explanation pleaſes me much. Now, my dear Elizabeth, I have a queſtion to put to you: The withered ſkin of a ſtale apple loſes its wrinkles and becomes ſmooth in the recipient? Tell me the reaſon of this.

ELIZABETH.

The air which is under the ſkin extends itſelf and raiſes it. It becomes more wrinkled than before when you withdraw it from the recipient, becauſe the air contained in it, having taken a larger ſcope, has nevertheleſs only gone out in part; conſequently the air in the apple being leſs, it has leſs power to repel the preſſure of the external air; and for theſe reaſons the wrinkles of the apple muſt be augmented.

LADY CAROLINE.

From an air-gun (which is a ſpecies of arquebuſe, made up of two metal barrels placed one in the other, and between which there remains a ſpace accurately ſhut up, where the air is ſtrongly condenſed by means of a little treading pump lodged in the but-end), how can one ſhoot many balls one after the other? and whence comes this force, Henry?

HENRY.

The condenſed air betwixt the two barrels makes a ſtrong effort to get out; as ſoon as it has effected this, by means of the barrel, it carries off every thing it meets with; the ball then receives a velocity almoſt equal to that with which the air flew off; but as the ſucker of its pump does not remain open for an inſtant, there flies from it at every time as much as is neceſſary to ſend the ball to an immenſe diſtance. If you then charge again, and put the gun on its cock, another ball darts from it.

In this gun, the laſt balls are impelled with a great deal more power than the firſt, becauſe the ſpring of the air diminiſhes in proportion to that which flies out of it, and gives a much wider ſpace for it to extend its power.

The noiſe of this gun is more weak than

that of a common one, becauſe neither the ball nor the air which impels it ever ſtrike the air with ſuch forcible velocity as a charge of inflamed powder, of which the exploſion is made with incredible rapidity. The report of the arquebuſe may be heard in the moſt immured receſſes, even without the leaſt kind of aperture.

LADY CAROLINE.

We throw into a clear fire ſmall globules of glaſs, which burſt with a very loud report. What is the cauſe of this, Fanny?

FANNY.

A violent heat dilating the air contained in the globules (or what my brothers call crackers) makes it act within them with ſuch force that they fly to pieces. The proper name of this globule is what Sir Thomas calls *eolipile*, Madam, if I am not miſtaken.

LADY CAROLINE.

You are very right, Fanny, and it pleaſes me to hear you expreſs with technical propriety ſo common an incident. Cheſnuts burſt under great heat. Why ſo, Mary?

MARY.

The air contained under the rind being dilated by fire, acts againſt it to make a free vent for its liberation. The more the rind reſiſts, the more loud is the rupture, becauſe the air has the time of being more dilated, and of courſe acts with greater force.

This effect does not take place when we remember to cut the rind previous to their being put to the fire; the reaſon of this is, that the dilatation of the air finds an eaſy iſſue, and conſequently makes no kind of effort.

LADY CAROLINE.

Very juſt, my dear Mary. When we heat a bottle, Edward, of which the neck and the orifice are ſo very narrow, that there are no means to fill it, not even by the uſe of a funnel, why do we very eaſily conquer it, after having heated the bottle, and plunged its orifice immediately into the liquor we wiſh to introduce into it?

EDWARD.

By dilating the air by heat, we force a great part of it to iſſue out, and that which remains, beginning to condenſe in proportion as it cools, leaves a vacuity, at which the weight of the atmoſphere conveys in the liquor.

LADY CAROLINE.

The air of a chamber is rarefied when there is a lighted ſtove in it. How does this happen, Sophia?

SOPHIA.

The cauſe of this is, that the air is not ſo much confined, but that it can communicate a little with that on the outſide the room, by ſmall chinks or apertures which happen to be in the doors or the windows, where the air from the ſtove has liberty to extend itſelf.

We muſt obſerve, that the air of this

chamber, thus rarefied, and leſs denſe than the atmoſphere, muſt hold in equilibrium with it; becauſe, by heating, it acquires a degree of ſpring which enables it to ſupport the preſſure of the atmoſphere. The ſame cauſe which diminiſhes its denſity, by ſo much the more increaſes its ſpring, and one is a ſuccedaneum to the other.

LADY CAROLINE.

How does it happen, that when we light a fire in the chimney-place of a room, the air is thereby rarefied without any increaſe of its ſpring? Tell me, Frederic.

FREDERIC.

As ſoon as the equilibrium ceaſes betwixt the two columns of the atmoſphere correſponding to the openings of the two extremities of the chimney, that which weighs below having all its denſity, ſurpaſſes the other which is partly rarefied, and then there occurs a current of air from the lower extremity to the upper.

The ſmoke, inſtead of ſpreading itſelf in the chamber, takes its vent up the chimney, becauſe the air of it, being rarefied by heat, reſiſts leſs the ſmoke than the air of the chamber, and the ſmoke impelled forward by the fire muſt of neceſſity deſcribe a right line, or any other paſſage open for its aſcent.

LADY CAROLINE.

In the operation of cupping, we apply upon the ſkin a ſmall veſſel of glaſs, which acts as a recipient, and which at its cope has an aperture to which we adapt a ſmall pump; when a vacuity is made through this pump, the ſkin ſwells under the recipient or glaſs. Give me the reaſon, George, if you can?

GEORGE.

The air contained under the ſkin, finding no longer the reſiſtance of the atmoſphere, raiſes by dilatation the ſkin produced by the effects of the operation; and when it is ſufficiently pulled up, the recipient is taken off, and we ſcarify the part thus puffed up with ſmall lancets made for this purpoſe.

LADY CAROLINE.

Why, Kitty, does a bird placed in a recipient, of which the air is conſiderably rarefied, ceaſe breathing?

KITTY.

This air no longer participating with the weight of the atmoſphere from which it is ſeparated, its ſpring, as well as its denſity, being very much diminiſhed, it is impoſſible for the lungs of any animal to dilate, becauſe the fluid which is accuſtomed to be there inhaled, ceaſes to exiſt; thus the alternate motion which we call reſpiration, cannot any more have place, ſince of the two powers which produce it, we ſuppreſs one and weaken the other, by the abſence of the indiſpenſable weight and ſpring of the air.

Another cauſe gives death to the confined animal; which is, that the air contained in the different capacities, and even in the fluid fluids of its body, ſtrongly rarefies when it is no longer ſupported by the preſſure of the external air. All theſe portions of dilated air, acquiring a volume much greater than that which they had in their natural ſtate, compreſs, and often break the parts where they are engaged; or, rather, where they make obſtructions in the veſſels, and arreſt the courſe of the humours.

Animals uſually are ſick, or evacuate, when we pump out the air from the recipient in which we place them, becauſe the air of the inteſtines of the ſtomach, being greatly extended, throws up the undigeſted aliment, or precipitates the excrements which nature has allotted to deſcend.

LADY CAROLINE.

Whence comes the air which we ſee iſſue from a fiſh when put into a veſſel of water and covered with the recipient? Tell me, William.

WILLIAM.

This air was in the body of the animal, but it flows out in the ſhape of bubbles, which appear upon the ſurface of the water proportionably to the void in the recipient, becauſe it finds leſs reſiſtance on the part of the rarefied air which ſurrounds the fiſh.

LADY CAROLINE.

Why, Kitty, does not the privation of air give death ſo ſoon to aquatic and amphibious animals, as to others?

KITTY.

There is every appearance that the firſt have a different way of reſpiring from the others. An air more rarefied may therefore be ſufficient for them. However, there is that which moſt accelerates their death in the void; it is the internal air which dilates and puts the whole ſyſtem of the animal into a ſtate of agitation and deſtruction.

LADY CAROLINE.

Why, Elizabeth, does a carp ſwim only on the ſurface of the water, notwithſtanding its inclination to the contrary when it is placed in a veſſel under the recipient ?

ELIZABETH.

Becauſe the double bladder which we find in this fiſh, as well as in many others, is diſtended on this occaſion, and blows up the body of it, which now becomes lighter than the volume of water to which it correſponds, and conſequently it muſt ſwim on the ſurface of the water.

The ſame fiſh becomes leſs, and is involuntarily precipitated down, when the air is allowed to re-enter the recipient, becauſe the little bladder, by dilatation, is partly voided, and the remainder of the air which it contains, when it reſumes a denſity equal to that of the atmoſphere, is no more capable of filling it, as it may be proved by opening the body of the fiſh.

LADY CAROLINE.

How, Henry, do almoſt all inſects, even thoſe which live in the open air, ſuch as butterflies, common flies, and ſcarabees (a kind of beetle), ſuffer, without periſhing, the privation of air, ſometimes for fourteen or fifteen days?

HENRY.

As they have in their bodies but very ſmall volumes of air, the dilatation is extremely minute. The void cannot be mortal to them, but through the want of reſpiration. Theſe little animals may probably be a long time without reſpiring even the groſſer air. However, Madam, I dare ſay that you will agree to this, that the natural ſtate of all theſe animals is to breathe.

LADY CAROLINE.

It is evident, my dear Henry, that they breathe, though the air may never be too rarefied for them; and as they can ſupport the recipient ſo long as fourteen or fifteen days, you may be aſſured that it is the want of food which cauſes their death, and not the want of air, which I might have previouſly explained to you. However, my dear Fanny, can you explain to me the cauſe of fiſh dying under the ice?

FANNY.

They die through the want of air, ſince we may avoid this accident by taking care to break the ice.

LADY CAROLINE.

Why do dogs, cats, and the young of rabbits, not die in the recipient as ſoon as thoſe full grown? Tell me.

[*Here Sir Thomas propoſed to anſwer Lady Caroline himſelf.*]

SIR THOMAS.

The reſpiration is of more urgent neceſſity for the full grown than the young ones. To feel the difference of them, we muſt know that, before the young is brought forth, there is only one circulation for the dam and it. In this laſt, which does not yet reſpire, the blood goes from the right ear to the left auricle of the heart, by a communication which the anatomiſt has called the *oval orifice*, and without being obliged to paſs by the lungs, where the external air has no kind of acceſs: but after the birth, this paſſage gradually ſhuts up, and reſpiration becomes neceſſary to ſwell the bladders of the lungs, and to make the blood circulate in young animal's newly from their dams, in the ſame manner as the reſpiration of this laſt made it previouſly circulate in both.

Many little ſtories have been related concerning perſons who were ſaid to have been hours, days, and even weeks in the water, and under ice, without having been drowned. If theſe accounts be true, I do not know how to explain them, unleſs by ſuppoſing that theſe perſons had the oval orifice ſtill open.

LADY CAROLINE.

Why might we not ſave the lives of many perſons who have not been too long in the water, if inſtead of holding them ſuſpended, the head downwards, and often in a cold a cold chill air (which is the cuſtom in many places, and actually effects their death), we endeavoured to re-animate the blood by a gentle heat, by ſpirituous liquors, by friction, and by holding them up in a natural and commodious ſituation? Can you explain this, Edward?

EDWARD.

Although their ſtomachs may be overcharged with water, this is in reality the ſlighteſt conſideration: the firſt object ſhould be to aſſiſt and re-animate ſuſpended circulation.

LADY CAROLINE.

If any animal be ſuffered to remain in a fluid a few degrees more denſe than the common air, it will die in the ſpace of five or ſix hours. What is the cauſe of this, Sophia?

SOPHIA.

Violence is done to it by breaking the equilibrium betwixt the internal air of their bodies, and that which ſurrounds them.

Nor would animals ſcarcely exiſt any longer, were they pent up in a foul and unwholeſome incloſure, preſſed one againſt the other, and never renewing the air they inhale: for the air loſes its ſpring by ſtaying too long on the lungs, or in the ſanguine veſſels; and, its elaſticity being deſtroyed, it is no longer capable of giving reſpiration.

LADY CAROLINE.

A lighted flambeau, expoſed againſt the ground in the celebrated grotto of the Dog in Italy, is extinguiſhed in a ſecond of time. Can you form any idea of what may be the reaſon, Frederic?

FREDERIC.

I ſhould imagine that it is owing to ſulphureous exhalations, which, I have heard your Ladyſhip ſay, aſcend in great quantities from the bottom of this grotto. I likewiſe remember your Ladyſhip telling us, that if a dog were thrown into it, he would immediately die; which I attribute to the ſame cauſe, the ſulphur overpowering and ſuffocating the animal.

LADY CAROLINE.

Why does a candle go out when it is ſhut up in a vault full of wine in fermentation? Tell me, George.

GEORGE.

It is becauſe the volatile ſpirit contained in the wine diſſipates and fills the vault with exhalations, which exhalations extinguiſh the light of the candle.

Thus alſo the exhalations of burning copper, ſhut up in a glaſs, will ſuffocate, in a very ſhort time, any animal that may be held over it.

Hence thoſe who work in mines, either of coals or of metal, die on the ſpot, when certain exhalations ſuddenly ariſe from the bottom of the quarry.

Again: a man who ſhould place his noſe to the bung-hole of a tun of wine in fermentation, and ſhould breathe but once over the exhalations, would be ſtruck dead immediately, as if with a thunder-bolt.

Obſerve another inſtance: maſter brewers have frequently found their draymen dead in their brewhouſes full of fermenting porter, the conſequence of having imprudently ſhut all the windows during winter, for preſerving themſelves from the cold: it is therefore abſolutely neceſſary, for avoiding ſuch fatal accidents, to open every paſſage of the brewhouſe in winter as well as ſummer.

LADY CAROLINE.

Why is it unwholeſome to remain a long time, nine or ten hours for inſtance, in a bed of which the curtains are extremely thick, and cloſely ſhut? Tell me, Kitty?

KITTY.

Becauſe the ſmall maſs of air contained within, not being renewed as it ought continually to be, its purity cannot fail of being adulterated by the inſenſible tranſpiration and reſpiration of the body.

LADY CAROLINE.

To what cauſe muſt we attribute epidemic maladies, or contagious diſeaſes, which ſpare not the king any more than the beggar? Tell me, William.

WILLIAM.

They are to be attributed to an infected air, the effects of which are experienced by communication, or by the winds and other changes in the atmoſphere.

LADY CAROLINE.

In great heats we have recourſe to freſh drinks, to bathings, to cold liquors, to ice. What is the reaſon of all this, Elizabeth?

ELIZABETH.

It is that the air, which by this means we contract, may, after enlarging itſelf, re-eſtabliſh the vigour, by removing the oppreſſive languor of the body which the heat had cauſed, and thus, by continued incitements to digeſtion and nutrition, we conquer that heat.

LADY CAROLINE.

Why do the moſt combuſtible matters refuſe taking fire in an air that is not free; and why, when they are ſet on fire, are they ſuddenly extinguiſhed in the recipient, Henry?

HENRY.

As the flame conſiſts in a motion of vibration, impreſſed on the parts of combuſtible bodies, which are diſſipated under the form of an extremely ſubtile fluid, this motion cannot have place but in a ſpring medium, capable of re-action, which reſtrains the flame of it. Now this ſpring fails both in the recipient and in an air that is not free. It thence follows, that a candle is by degrees extinguiſhed under the recipient, in proportion as the air is rarefied. Gunpowder thrown upon a burning hot metal, previouſly placed in the recipient, where the vacuity is afterwards made, produces nothing but ſmoke, or at the moſt a very feeble flame, which in an inſtant goes out: this ariſes from the ſpring of the air diminiſhing in proportion as the fluid is rarefied; for the vibrations of the flame experience no more the re-action of the fixed part.

If, however, we employ, by degrees, a certain quantity of powder, that which ſhould fall the laſt into the recipient would infallibly be inflamed, and might blow up, with very great danger to the manager of the machine; becauſe the ſulphur and the ſalt-petre burning, produce air in the recipient, and this air increaſes the ſpring of that which is in the vaſe. Thus, you have nothing more to do, but throw ſome grains of powder upon the burning metal, to make a ſmall quantity of air iſſue from theſe grains; which, however, is incapable of conſiderably increaſing the ſpring of that which was rarefied in the recipient.

LADY CAROLINE.

Why are a lighted *bougie* or a red hot

coal extinguiſhed when we put them into inflammable liquids, ſuch as ſpirits of wine, oil, &c.? Tell me, Fanny.

FANNY.

Theſe liquids are ſo very compreſſible, that we muſt look upon them as deſtitute of the neceſſary degree of elaſticity; for the flame cannot riſe nor be kept up, but in a ſpring medium.

A lighted bougie, or a red hot coal, however, communicates in a moment fire to ſpirits of wine and to oils, when theſe ſubſtances are, by burning, reduced into vapours. In the ſtate of vapour theſe bodies are mixed with air, and form with it an elaſtic fluid, of courſe, capable of a reaction, ſuch as is neceſſary to ſupport the inflammability.

LADY CAROLINE.

Why does the fire burn a great deal better, and fuel more quickly conſume, during froſts, than at any other time? Tell me, Mary.

MARY.

It is becauſe the air is more denſe, and that there is a greater ſpring in froſty weather. A chafing-diſh full of lighted charcoal extinguiſhes very ſoon if it be expoſed to the heat of the ſun, particularly during the ſummer, becauſe in the dog-days the air has the leaſt ſpring, being then the moſt rarefied, that is, more extended, and occupies more ſpace.

LADY CAROLINE.

Why do conflagrations uſually ceaſe, when they penetrate into places where every aperture may be cloſed up, provided their walls are likewiſe able to withſtand the efforts of the air and the vapours which dilate within? Account for this, George.

GEORGE.

It is not enough that there be air around the inflamed materials to keep up the fire, it is neceſſary that this air be free, and that it have a certain purity. Now, when a place is well ſtopped up, the air has loſt its freedom, and heterogeneous particles iſſuing from the inflamed bodies, corrupt and deaden it.

LADY CAROLINE.

How does the breath of the mouth, or wind, put out a wax-candle, Mary?

MARY.

It diſſipates the parts of the flame, and ſeparates the fire from its aliment; for every time that this diſſipation does not take place, the fire, far from ceaſing, increaſes.

LADY CAROLINE.

When we attempt to raiſe fires in the void, and particularly thoſe which originate in fermentation, why does the recipient fly into pieces to the great danger of the ſpectators?

EDWARD.

The liquors adapted for raiſing fires in the void, being ſo much the more active, as they are leſs conſtrained by the weight of the atmoſphere, their exploſion muſt naturally be more violent in the void than any where elſe, whether they produce by fermentation a great quantity of air, of which the ſpring is inſtantaneouſly diſplayed, or whether (and this is the beſt reaſon), being reduced into vapours, they dilate themſelves by their own conflagration.

LADY CAROLINE.

Here is a glaſs of clear water, in which I put a piece of wood or ſtone, a nut, an egg, or other ſolid porous body, in ſuch a manner that they may be entirely covered with the water. To effect this, I make uſe of a ſmall piece of lead tied to the ſubſtances which do not ſink, in this inſtance the *nut* and the *piece of wood*. I now take the glaſs and place it upon the platen of the machine with the recipient over it; then make the pump act to rarefy the air. At every blow of the ſucker you obſerve that there iſſue out innumerable bubbles of air from the bodies at the bottom of the glaſs.

I will now take out one of the bodies, the nut, for inſtance, which you may ſee is penetrated by, and filled with the water, more than it could poſſibly have been by a ſimple immerſion. Can you account for this, Sophia?

SOPHIA.

The air which is incloſed in the pores of the wood, ſtone, and other bodies, which your Ladyſhip put into the glaſs of water is, at leaſt, as denſe as that of the atmoſphere, of which it ſupports the weight. When you ſuppreſs that reſiſtance, or diminiſh it by the action of the pump, this air is dilated by virtue of its ſpring; its volume increaſes, and, unable to remain any longer in the ſmall ſpaces which contained it, it flies into the water, and becomes viſible under the form of little globules, which rapidly riſe on account of their reſpective lightneſs.

The air which paſſes from the ſolid body into the water which ſurrounds it, is formed into little balls, and this happens, generally ſpeaking, to every fluid which is plunged into another fluid with which it cannot mix but with great difficulty; and for this reaſon, that all its parts, equally preſſed on every ſide, tend to one common center.

When you permit the air to re-enter the recipient, the water in the glaſs is more compreſſed than it was when in the rarefied air; it conſequently ſupports itſelf upon all the ſurfaces of the bodies which your Ladyſhip put into the water. The air which has been rarefied in the pores of the nut, obeys this new preſſure, contracts itſelf into a ſmaller ſpace, and the water tends to fill the voids which the air has left. This is the reaſon, that when theſe bodies are opened after the experiment, we ſee the objects penetrated by and filled with water.

LADY CAROLINE.

Why do theſe drops of water and of mercury, which you ſee I have placed in the recipient, ſtill keep their natural globular form, Frederic?

FREDERIC.

Their parts tend to a common center, being equally preſſed on every ſide, juſt as they are in the recipient; for we cannot imagine that it is a real void; it is but a rarefied air. There is always in the recipient a fluid independent of that which iſſues by means of the pump.

LADY CAROLINE.

In proportion as I rarefy the air of the recipient in which I have, as you ſee, placed a champaign glaſs exactly two thirds full of champaign wine, the air which it contains diſengages itſelf and riſes to the ſurface, on which, you may obſerve, it cauſes foaming. You now ſee it ſpouting forth to a conſiderable diſtance ſparkling globules which increaſe in number and in ſize, flying more and more diſtant. Give me the reaſon of this, George.

GEORGE.

As you ſuppreſs by rarefaction the external air, you give room to that in the champaign to diſengage itſelf; for, being no longer loaded as it was before, it acquires a greater volume; and its reſpective lightneſs, now more powerful than the friction, and the other cauſes which tended to reſtrain it, fails not to elevate the liquor to the ſurface.

LADY CAROLINE.

I now put into the recipient ſpirits of wine, and luke-warm water, in theſe two glaſſes ſeparately. I then draw out the air to a certain degree, and you ſee they all on a ſudden guſh over their ſurfaces in copious ebullitions. How is this brought about, Kitty?

KITTY.

The more eaſily a liquid ſeparates, the more quick and more large are the bubbles of air that aſcend from it; for it finds a leſs reſiſtance to conquer in the enlarging itſelf to a greater expanſion. Now, ſpirits of wine and luke-warm water, I have heard your Ladyſhip ſay, are very fluid and eaſy to be ſeparated.

LADY CAROLINE.

You are very right, Kitty. I now put into the recipient, beer in one glaſs, and milk in another. You perceive that they riſe up into a high froth; ſo much ſo, that the glaſſes are become wholly empty. Explain the cauſe of this, William.

WILLIAM.

The beer and the milk, being of a viſcous nature, are divided with difficulty: the globules of air which are formed in it, remain enveloped in minute bladders, and riſe very ſlowly; and as they are conſtituted of particles of the liquors which are difficult to ſeparate, the bubbles of air, by carrying them off, empty the glaſſes.

In theſe experiments, Madam, we obſerve that the bubbles of air increaſe in volume as they approach the ſurface of the liquors.

quors. As they aſcend, they have a leſs weight to ſupport, and, of courſe, their dilatation is increaſed.

LADY CAROLINE.

Butter, reſin, melted gum, and other liquids of a ſimilar nature, ſwell by degrees, and ſurprize us at firſt with their ſudden effervеſcence; they are frequently alſo very dangerous in boiling. Can you account for this, Elizabeth?

ELIZABETH.

The groſſer parts of the air are mixed with theſe coarſe liquids, and when put on the fire, being already inflammable in their own natures, the perſons who are in the room, and the houſe itſelf, are in the utmoſt danger.

LADY CAROLINE.

The air that is extracted from leavened paſte, from fruits, and from the greater number of vegetables, ſuffocates animals, extinguiſhes fire, and ſtrikes our ſenſe of ſmelling with a very annoying and piercing odour. To what, Henry, do you attribute this?

HENRY.

This air is not only impure, but actually poiſonous. It is a compound fluid, partaking very much of the nature of whatever it flows from, and is loaded with a copious vapour, which makes up the greateſt part of its volume.

LADY CAROLINE.

How do perſons who drink in too great quantity of ſpirituous and fermented liquors deſtroy their lungs and coagulate their blood? Tell me, Fanny.

FANNY.

All ſuch liquors, in general, as well as crude aliments, contain and convey with them a great quantity of tainted air, which is afterwards dilated with alarming efforts in the ſtomach.

A moderate uſe of aliments, as well in beverage as in food, is what every body ſhould obſerve for the preſervation of their health.

LADY CAROLINE.

We call a certain appearance of the air and ſky, a ſerene heaven. How is that appearance cauſed, Edward?

EDWARD.

During the day, the rays of the ſun heat at the ſame time both the earth and the air which environs it. When the ſun is ſet, the heat that it had communicated, abates imperceptibly; but it preſerves itſelf a longer time in bodies which poſſeſs more matter, ſo that during the night, the earth and the waters are commonly more warm than the air of the atmoſphere. Then the matter of fire, which tends to expanſion, always uniform with the nature of the fluids, paſſes from the earth into the air, and carries with it the more ſubtile parts of terreſtrial bodies, which it detaches and animates by its motion. On this account, that part of the atmoſphere which is neareſt to the earth receives a greater quantity of theſe evaporated ſubſtances. Hence that moiſture which we very often feel upon our clothes when we walk out in the freſh evenings of ſpring and autumn; and this we call a ſerene heaven.

LADY CAROLINE.

Whence proceeds the dew? This is an intereſting ſubject, and I wiſh you would explain it at large, Frederic.

FREDERIC.

The ſerenity juſt ſpoken of laſts all the night in the ſeaſons, and in the climates, where the earth receives a genial heat during the day. At the riſing of the ſun, the heat begins to warm the atmoſphere, and the air beginning to dilate, drops its vapours, too ſubtle to fill its pores, or rather, they follow the matter of fire, to which they are ſtill united, and return them towards the earth. Such vapours, and ſo falling, we call dew.

LADY CAROLINE.

Whence comes the hoar froſt? Can you tell me, Mary?

MARY.

The ſmall drops which make the dew, are frozen into a feathery kind of ice by a cold air. It is this kind of froſt that melts and diſſipates as ſoon as the ſun begins to make its heat felt.

LADY CAROLINE.

What are miſts, Kitty?

KITTY.

They are a large thick expanded heap of vapours, and groſs exhalations, which their own gravity or violent cold condenſes, and hinders from riſing any higher than a ſmall matter above the ſurface of the earth, which moiſtens it with unwholeſome damps. The ſevere cold, which unites the groſs vapours and ſickly exhalations, makes the groſs miſts very malignant. England, I believe, is the only iſland that is infeſted with theſe unwholeſome damps.

LADY CAROLINE.

Why, George, in froſty weather, are the windows of our chamber frozen within and not without?

GEORGE.

The air is warmer within our chambers than it is without, ſo that the fire which paſſes through the humid vapours, runs out, always tending to ſpread itſelf in a uniform manner. It carries off, of courſe, the vapours, but it leaves them on the inſide of the panes, to which they adhere, and, in ſpite of the warmth of the chamber, are frozen on every pane, ſometimes ſo thick that we cannot ſee through them.

LADY CAROLINE.

Of what are the clouds compoſed, Kitty?

KITTY.

Of certain miſts or vapours, which, when riſen to a proper height, become great maſſes, and are floated by the wind through the atmoſphere. Such are the clouds which we ſee ſuſpended on all ſides, and above our heads, and which occaſionally hide from us, in their courſe, thoſe beautiful objects, the ſun, moon, and ſtars.

LADY CAROLINE.

How is rain formed, William?

WILLIAM.

The clouds often become very thick, either by the action of the winds, which puſh them one againſt another, or by the condenſation of the air on which they are borne. Their parts, re-united into large drops, become too heavy, and make, while they are falling, what we call rain.

LADY CAROLINE.

Whence comes rime, Elizabeth?

ELIZABETH.

From a miſt, which cold weather freezes and attaches to the branches of trees, to dry plants, to the hair of travellers, and, generally, to every thing expoſed to it. The rime owes likewiſe its origin to the dew, which tranſpires from the veſſels of plants during the night.

Rime alſo announces thaws; becauſe when the rime appears, it is a ſign that the air is full of humid and warm vapours.

LADY CAROLINE.

It has been ſaid, as ſome of you, my dear children, have read, in Titus Livius, and other eminent ancient authors, that ſhowers of blood, of ſulphur, of ſand, &c. have been ſeen. If theſe could poſſibly happen, what could produce them, George?

GEORGE.

Let us ſuppoſe, for an inſtant, the truth of all the phenomena which have been related upon this ſubject. It may be allowable to ſay, that thoſe kinds of rains, while thus falling, produce copious and different exhalations. But although Plutarch, as well as others, ſpeak of raining blood, I cannot be brought to believe that it was real blood; I am perſuaded of the contrary, and that this blood did not fall in the manner of rain.

In order the more eaſily to conceive what

I mean, you will have only to attend ſeriouſly to my illuſtration.

When a butterfly iſſues out of its chryſalis, it always lets fall two or three drops of a red ſerous fluid, which reſembles blood. Now there are times in which a prodigious number of theſe animals ſwarm in the nether regions of the atmoſphere; for this ſpecies of inſect, like moſt others, is extremely prolific, and if all their eggs were to turn out well, thoſe who live in the countries where they abound, would be very much incommoded with them.

When a great ſwarm of caterpillars become chryſalis, and are changed into butterflies, what immenſe numbers of thoſe red drops muſt be ſeen! eſpecially as there is a ſpecies of them which ſtick to walls and buildings, for there are many that never leave the earth; ſome alſo there are, that cling to the ſtems of plants, and then we ſcarcely perceive the traces of their metamorphoſes?

Were any one ſeriouſly to tell me that he had ſeen it rain ſhowers of toads and other animals, I ſhould immediately reply, that the male and female could not be in the atmoſphere on account of their weight. It were much more rational to think that all theſe little animals, newly hatched, and hidden under the graſs and herbage, or any where elſe, were routed out by the rain from their neſts and hidden retreats to ſeek ſhelter: for how can any reaſonable being think that they could be produced fortuitouſly; or, allowing this, that the hard earth on which they muſt fall, would not with their own weight daſh them to pieces?

Let a countryman, after a heavy rain, bring me a handful or two of wheat, which he has juſt gleaned, and at the ſame time tell me that it has been raining corn, I ſhould ſmile at his ſimplicity, and prove myſelf as ſimple as he, were I to undertake explaining the cauſe of it to him.

LADY CAROLINE.

Your explanation of this phenomena is, my dear ſon, at once true, philoſophic, and ſenſible. How, Kitty, does rain purify the air?

KITTY.

It precipitates all the exhalations which are gathered together in the atmoſphere during the hot weather, of which a too great quantity would corrupt the air, and occaſion epidemic maladies. We ſenſibly feel the good effects of rain, not only by breathing more freely and ſweetly, but by the pure and tranſparent appearance of the air: objects are ſeen more diſtinctly and obſerved at a greater diſtance; for there never was a teleſcope that could ſhew a body ſo clearly as a ſerene heaven after a heavy rain.

Rain refreſhes the air, becauſe the region of the clouds whence it flows is almoſt always more cold than that part of the atmoſphere in which we are. This is a fact well known to thoſe who have ſeen high mountains covered with ſnow (which your Ladyſhip and Sir Thomas have mentioned to have yourſelves ſeen) when at the ſame time in the valleys beneath, the air has been very hot. Thus, when it rains in ſummer, the rain being cold water filtering through a heated air, this air muſt neceſſarily loſe a great part of its heat.

LADY CAROLINE.

Whence reſults the ſurpriſing and formidable phenomenon called the water-ſpout, which is very often ſeen at ſea, rapidly flowing down from the atmoſphere, and ſometimes on land? It is a thick black cloud which prolongs itſelf from the atmoſphere to the ocean, in form of a cylindrical column, or rather, an inverted cone; it throws about itſelf a vaſt quantity of hailſtones and rain, and makes a noiſe ſimilar to that of the ſea in a violent ſtorm. It tears up trees and houſes wherever it paſſes, and when it falls upon a veſſel, that veſſel is immediately ſunk by it. Seafaring men, who well know this dangerous appearance, ſail as faſt as they can from it, and when they cannot avoid approaching it, they endeavour to break it by cannon balls, and if they ſucceed in breaking it, the danger is avoided. I beg to aſk the cauſe of this phenomenon, Frederic.

FREDERIC.

Although few obſervers have had the opportunity of nearly examining it, I think that the cloud, determined to turn by the double impulſe of two contrary winds, of which the directions are parallel, takes the form of a watery whirlwind, which lengthens and enlarges itſelf more or leſs according to the velocity with which it turns, and follows the extent of the wind which agitates it.

LADY CAROLINE.

Excellent, Frederic. Now, Edward, tell me the origin of hailſtones.

EDWARD.

Vapours condenſe by cold weather, which freezes the aqueous particles, and they form themſelves into drops, ſometimes equal in ſize to a walnut or ſmall egg, becauſe many drops of rain are united together while falling; or rather, and they have received a ſufficient degree of cold, they freeze all the particles of water that they touch in their fall, and become like the ſtones of fruits, with many layers of ice. It is for this reaſon that large hailſtones are always angular, and that thoſe which are round, never are of a uniform denſity from the ſurface to the center.

Hailſtones which fall during a violent wind are generally of a leſs regular figure than the former, becauſe the wind makes the drops of rain loſe their roundneſs, and flattens them by compreſſion, in a manner which preſerves that form when they are frozen.

It never hails in thoſe valleys which have their reſpective mountains to the eaſt; the reaſon of which is, that the great quantity of rays which thoſe mountains reflect melt the hailſtones the moment they fall.

Previous to a fall of hail we ſometimes hear in the air a great and crackling noiſe. This noiſe is cauſed by the ſtones which are puſhed againſt each other by the wind; for as theſe little pieces of ice are hard bodies, they give a ſound ſimilar in their degree to all other hard bodies when impelled by each other.

LADY CAROLINE.

What is the cauſe, and what are the uſual effects of ſnow, George?

GEORGE.

The cold, in the region of the clouds, condenſes the vapours, and freezes the aqueous particles, prior to their union into large drops. Theſe infinitely thin flakes of ice conſiſt of the moſt minute particles of frozen vapours.

Snow contributes to the richneſs and fertility of the ſoil; as it confines the exhalations, and is accompanied with particles of nitrous ſpirits, the warm exhalations of which, joined to it, nouriſh and promote vegetation.

LADY CAROLINE.

Why, Kitty, does mercury aſcend in the barometer?

KITTY.

Becauſe it is impelled by a heavy column of air, which is extended to the very top of the atmoſphere. Thus, the heavier the air is, the higher the mercury aſcends; the leſs the air weighs, the lower the mercury deſcends.

LADY CAROLINE.

Why, William, do the vapours weigh leſs when they aſcend, than when they are motionleſs?

WILLIAM.

When a body of any conſiderable weight aſcends, it cannot preſs downwards with the ſame force as it does when ſuſpended in the air without any motion. The vapours which aſcend raiſe and make the air, againſt which they are driven, in a certain degree aſcend likewiſe; and as they are impelled to traverſe by riſing, this air then preſſes leſs downwards than before.

LADY CAROLINE.

If I pour on the lower mercury of a barometer fourteen inches of water, why, Elizabeth, does the mercury aſcend an inch in the tube?

ELIZABETH.

Becauſe an inch of mercury equilibrates fourteen inches of water.

If we put into this water the orifice of a ſyringe, and draw the ſucker, the water follows it; becauſe by lifting it up, every obſtacle to the elevation of the water, preſſed by the external air, is taken away, which weighs about twenty-eight inches of mercury.

LADY CAROLINE.

Why, Henry, do two pieces of poliſhed

marble, when rubbed againſt each other, cloſely adhere?

HENRY.

The internal air is driven out from betwixt them by friction; and the equilibrium betwixt this laſt air and the external air becoming ſtronger, acts in every direction, and weighing upon the two pieces of marble, attracts them together.

In the recipient they would eaſily ſeparate, becauſe the preſſure of the external air diminiſhing in the proportion of the rarefaction, weighs no longer ſo much on theſe two bodies; there is therefore leſs ſtrength required to ſeparate them.

LADY CAROLINE.

We are convinced, Fanny, by a great number of experiments, that the air above each part of a body preſſes it as much as if it ſupported twenty-ſeven inches of quickſilver, as you may obſerve upon the barometer at the twenty-ſeventh inch, or 14 times as many inches of water.

Suppoſing the body of a man to be ſix feet high and one foot broad, the air will preſs as much on each foot as if there were thirty cubic feet of water; each of which weighs at leaſt ſixty-three pounds. This number taken thirty times, makes one thouſand eight hundred and eighty pounds, which preſs upon every foot of our bodies, and conſequently all the width of the body ſupports ſix times this weight, that is, 11,348 in the fore part of our bodies, and as many behind, which, together, make 22,696 pounds weight. How can ſo prodigious a force be supported by a human being without cruſhing him to atoms?

FANNY.

This weight of air equally preſſes our bodies on all ſides, as well within as without; it therefore changes nothing in the diſpoſition of its organs. We know that the internal air of our bodies has the ſame force and the ſame ſpring as that which ſurrounds us. The forces being equal then, there muſt be an equilibrium, and conſequently the body will not be overpowered.

SIR THOMAS.

Having proceeded thus far, my dear children, your mother and I will now collect ſuch queſtions as will well fall in with the foregoing, and be equally as pleaſant, inſtructive, and eaſy. They will treat of ſound and of the winds, and will require no other definitions than their queſtions will naturally prompt, and your own judgements and knowledge well ſupply.

THE FIFTH CONFERENCE.

OF SOUND, AND OF THE WINDS.

LADY CAROLINE.

WHY, Edward, are clocks made of a metal compounded of tin and red copper?

EDWARD.

Becauſe every compound metal is more hard, more ſtiff, and conſequently more elaſtic, than the ſimple metals which enter into the mixture; and as ſonorous bodies are ſo much the more ſo, as their parts have greater ſpring, they make clock-bells of a compound metal, to draw more ſound from them. The greateſt number of ſmall bells, however, are only of copper; but it is a bad copper, adulterated, and eaſily broken, called by *workmen*, *brittle glaſs*.

As this ſubſtance is very ſtiff and brittle, it is more ſonorous than new copper would be, and more ſweet and ſoft, and is properly called *molten copper*. Silver hand-bells would have but very indifferent ſounds without alloy.

LADY CAROLINE.

On touching a bell with one's hand, or any other ſubſtance, its ſound immediately ceaſes. Why ſo, Mary?

MARY.

The ſound is formed by the vibrations of the particles of the bell, which vibrations are interrupted by the application of the hand or other ſubſtance.

LADY CAROLINE.

The bells of clocks, when they are covered with ſnow, produce only a dead kind of ſound, ſimilar to that of muffled drums at ſome funeral ceremonies. Account for this, Sophia?

SOPHIA.

The ſnow, in the ſame manner as the covering laid over the drum, interrupts the vibrations of the ſonorous body.

LADY CAROLINE.

Why does not a cracked bell ſtill preſerve its vibrations and uſual clear ſound? Tell me, Frederic.

FREDERIC.

Becauſe the limits of the cracked part reciprocally claſh, and do to each other what a ſtrange body would do in touching it, were it ſtill unbroken. The ſound would be probably leſs interrupted, if, inſtead of having a ſmall fracture it had been much larger.

LADY CAROLINE.

Why do clock-makers take great care that the clappers of clock-bells be ſuddenly made to riſe again upon the blow being given by the ſpring? Tell me, George.

GEORGE.

Becauſe they excite the ſound, and that they may not alter it by remaining too long applied to the ſonorous body; clock-makers are obliged to be particularly attentive to this part of their branch.

LADY CAROLINE.

Whence, Kitty, proceeds the ſound that appears ſtill continued to us, although it be not ſo, ſince it is only a ſeries of vibrations?

KITTY.

Becauſe the ceſſation from one vibration to another is too ſhort to be perceived.

LADY CAROLINE.

Why, William, do the buzzing of flies, and the chirping of graſshoppers, and of crickets, continue ſo long?

WILLIAM.

Theſe ſounds come not from their mouths. In the fly, it is a kind of beating of the wings. In the graſshopper and cricket, it is the beating of a ſpecies of drum, which they have in the belly, and ſometimes upon the back, as may be obſerved on certain graſshoppers which conceal themſelves in the buſhes, and which have no wings.

LADY CAROLINE.

Whence, Frederic, proceeds the ſound of the thong of a whip, which a carman or poſtillion ſuddenly ſmacks; the humming of a thin piece of notched lath, which boys call the bull-roar, and which is turned rapidly round with a piece of ſtring; and the whiſtling of a ſwitch, when we ſhake it with great velocity?

FREDERIC.

In all theſe caſes, as well as in many others, the fluidity of the air reſounds, the parts of which flow into vibrations from having been ſhocked by a ſolid body.

LADY CAROLINE.

Whence comes the ſound of a flute or of a whiſtle? Tell me, Henry.

HENRY.

From a certain volume of air, blown from the mouth of the player, which ſtrikes another maſs of air contained in the inſtrument; for the vibrations of wood are of no other effect than to tranſmit with more power the ſound already formed.

LADY CAROLINE.

How, Fanny, does it happen, that ſome people can break a wine glaſs with the ſound of their voice, by placing it before their mouth?

FANNY.

Becauſe they take the uniſon of the glaſs, and force, by the ſtrength of their voice, the magnitude of the total vibrations, and conſequently the particular vibrations from which theſe laſt flow. Now theſe latter vibrations cannot be formed without the glaſs being ſhivered to pieces; of courſe, when they become too great, the diſſipation of their own continuity produces the above effect. In a word, the force of the voice operates upon the glaſs in the ſame manner as the bow of a violin, which is too forcibly drawn over the treble.

LADY CAROLINE.

Why, William, when a drum is beaten beſide a calm body of water, do we perceive the vibrations upon its ſurface?

WILLIAM.

Becauſe the trepidation of the air communicates to the particles of water.

Thus, when we twang the cords of muſical inſtruments near the rays of the ſun, which diſcover the atoms that play in the air, we ſee in theſe corpuſcula, vibrations conformable to thoſe of the twanged cords, becauſe the vibrations of the air communicate to theſe ſmall bodies.

In the inſtance of ſtrong ſounds, ſuch as thoſe of church bells, the drum, and baſs viol, it often happens that the panes of windows, and even wainſcot partitions, trepidate. We ourſelves, likewiſe, feel emotions of a trilling nature within us. It is very eaſy to comprehend, that the air having received the vibrations of theſe different inſtruments, not only communicates to panes and partitions, but even makes our inſides ſhudder.

LADY CAROLINE.

Why does the bell of a clock produce no ſound when ſuſpended in the vacuity of the recipient? Can you tell me, Elizabeth?

ELIZABETH.

Becauſe a bell which makes its vibrations there, can communicate them to nothing; ſince, therefore, they only act when they tranſmit themſelves, they muſt of neceſſity remain in profound ſilence; though, in reality, as Sir Thomas has obſerved to us, there is no abſolute void in the recipient; yet the air that remains there is ſo very rarefied, that its too-relaxed parts have not ſufficient re-action. This ſubtle fluid is too defective in denſity to place the parts in a ſituation to act ſtrongly againſt each other.

LADY CAROLINE.

Why, Henry, does a bell, when placed alone on the platen or in the recipient, produce ſound?

HENRY.

Becauſe the ſound is tranſmitted by the ſolid bodies communicating on one part with the bell, and on the other with the external air.

Were the bell in a ſtate of ſuſpenſion, it would not, as my ſiſter Elizabeth has obſerved in the foregoing anſwer, produce any ſound.

LADY CAROLINE.

I take this repeater and fix it to the leaden platen, which is, as you may ſee, about five-twelfths of an inch thick; I now cover it with this ſmall recipient, the rim of which I cloſely ſtop round with melted wax. I now ſuſpend the whole by four united ſtrings from the top of the recipient, in order to plunge it into this large cylindrical veſſel, which contains about thirty pints of water, and entirely free from air.

We now hear the repeater ſtrike, although it be ſurrounded with many inches of water; but this ſound, as you all evidently hear, is very much weakened. Can you, Fanny, give the reaſon of this?

FANNY.

Becauſe the ſound is communicated from the repeater to the air that ſurrounds it; from the air to the recipient, from this to the water, from the water to the external air, and then to us. We may eaſily imagine that the ſound, paſſing through ſo many bodies of different denſities, muſt at laſt become exceedingly enfeebled,

LADY CAROLINE.

Whence, how, and where proceeds that rebounding of the voice, &c. commonly called echo? Tell me, Sophia.

SOPHIA.

From a ſlow and reflected ſound which comes with the ſame modification as the direct ſound, and ſtrikes the organ of hearing, whence the direct ſound makes no more impreſſion.

Theſe reflections of ſound are never heard in open fields, but frequently in groves and woods, among rocks, and on the ſides of high, irregular, and craggy mountains; becauſe in theſe laſt places, the ſound very often meets with obſtacles which reflect it; this does not happen in free, open, and unconfined ſituations.

Echo repeats more of theſe reverberations by night than by day; becauſe in the ſilence of the night, the tranquil air, either leſs agitated or leſs charged with vapours and exhalations than by day, more eaſily conveys to, and receive its impreſſions from, a greater diſtance.

A ſolid ſurface is fit for echo; becauſe it reflects the ſound with the ſame circumſtances as the direct ſound.

A concave ſurface is alſo adapted to echo; becauſe it hinders the diſſipation of ſounds, and confines it to a certain ſpot.

There is no echo when the ſurface which ſhould reverberate, is too near us; becauſe it reflects the ſound before the impreſſion of the direct ſound be paſſed; then two ſounds make only one, which is that we firſt heard.

There is no echo when the ſurface which ought to reflect is too low; becauſe the air, which has received the vibrations of the ſound paſſing above the ſurface, is not reflected toward us.

LADY CAROLINE.

How, George, does muſic cure the bite of a tarantula?

GEORGE.

The venom of the tarantula thickens the blood, and ſtops many conduits of it: hence reſult dullneſs, numbneſs, and melancholy. Theſe, furniſhing very few animal ſpirits, their conduits ſink down in the brain; the nerves, deſtitute of ſpirits, are relaxed: hence inaction, the deprivation of underſtanding and memory, all of which are experienced by the perſon bitten.

The vibrations of lively tunes agitate the blood; and the ſmall remainder of animal ſpirits are ſoon multiplied by this agitation, and flow into the fibres, nerves, and the reſt of their accuſtomed channels.

Theſe, put in uniſon with the ſonorous cords, receive their vibrations, which, alternately ſhortened and prolonged, produce inceſſant dancing. This action of continued and hard dancing, heats and agitates the blood, and puts the patient at laſt into a violent perſpiration. The attenuated and diſperſing venom by degrees then exhales, and he begins to feel alleviated. This relief makes him a great deal more eager to reſume his dancing; till, all the poiſon being diſſipated by prodigious exerciſe and conſequent perſpirations, the blood returns to its former fluidity and uſual courſe, the poiſon now having totally gone off by perſpiration.

LADY CAROLINE.

Why, Sophia, ſince we have two ears, do we hear only the ſame ſound at once; and having two eyes, perceive only one object at the ſame time, and have not a double ſight?

SOPHIA.

SOPHIA.

In the firſt inſtance, becauſe the ſound attacks parts perfectly ſimilar, which poſſeſs one point of common re-union in the brain. There is then but one impreſſion in it, which muſt be very ſtrong, ſince it is formed by the two auditory nerves being united. Thus, by having two ears, we hear better than if we had but one of theſe organs.

Exactly the ſame reaſon may be given for our ſeeing with two eyes but one appearance of any object.

LADY CAROLINE.

My dear Sophia, among the many different tones, there are ſome which are better underſtood than others by certain perſons who are very hard of hearing. The efficacy of ſome ſounds compared with others, may be attributed to ſome defect of the ſpiral wave, which is affected but in part. If, for example, the two extremities of this part were become leſs ſenſible, by ſome accident, than the middle of it, the perſon who had this defect would hear with eaſe only ſounds of a mean proportion betwixt the high and low. In a numerous company he would aſſuredly find ſome one, whoſe tone of voice would happen to agree exactly to this ſound part, and who would make himſelf be perfectly heard by him, without ſpeaking any louder than common.

SIR THOMAS.

We will now, my dear children, proceed to the explanation of the phenomena of the winds, with their general cauſes: on which ſubject Lady Caroline will entertain us, by her uſual, pleaſant, and eaſy inquiries.

LADY CAROLINE.

What is the wind, George?

GEORGE.

The wind is a violent agitation in the air; and though there be as many different winds as there are different points in the horizon, we yet diſtinguiſh four principal ones. Theſe blow from the four cardinal points of the ſphere, and are, the wind of the north, that of the ſouth, that of the eaſt, and that of the weſt. To theſe four winds we add twenty-eight others, thus dividing the horizon into thirty-two principal parts, which make up the common diviſions of the compaſs.

LADY CAROLINE.

Whence come the winds in general? Can you tell me, Edward?

EDWARD.

From a defect of equilibrium in the air; becauſe every time that certain portions of the atmoſphere become more charged, more denſe, more elevated, or more preſſed than others, being more heavy, they muſt fly off, ruſh forwards through thoſe ſpaces where there is the leaſt reſiſtance, and puſh before them the other parts more weak; nearly like the water of a channel, raiſed by the throwing of a large ſtone into it, which moves the water in undulations, that is, wave over wave, ſimilar to the reſiſtance of the winds.

LADY CAROLINE.

Why do certain winds blow by ſhakes and ſudden guſts? Tell me, Henry.

HENRY.

Theſe winds are produced by exhalations congregated and fermented together in the middle region of the air; which fermentations are ſudden and intermittent exploſions, that conſequently puſh the air by ſudden attacks.

LADY CAROLINE.

Why does a very impetuous wind riſe ſometimes all on a ſudden, when a cloud is ready to burſt, during calm weather? Tell me, Fanny.

FANNY.

The cloud preſſes the air betwixt itſelf and the earth, and is forced to ruſh rapidly down. Theſe violent ſorts of winds are uſually followed by rain; becauſe the clouds falling produce it, and form it into drops during its fall.

LADY CAROLINE.

Whence, Mary, comes the ſpring zephyr?

MARY.

It probably originates in the great quantity of air which, from the atmoſphere, paſſes into different mixed bodies that nature produces where leſs ſpace is occupied. There is, therefore, in the atmoſphere, a ſmall defect of equilibrium, produced by a gentle wind, called zephyr.

The zephyr of autumn probably comes from the air, which at this time iſſues from bodies that are diſcompoſed. It is very certain that all bodies contain air, which, by being diſcompoſed in the atmoſphere, increaſes its volume, and deſtroys a part of the equilibrium which there prevails. The atmoſphere being then a little agitated, we feel a light and gentle breeze, which we call zephyr.

LADY CAROLINE.

Why, Edward, during the ſummer, is the riſing ſun frequently accompanied with a little wind?

EDWARD.

Becauſe the heat of the ſun, rarefying the air, forces it to occupy a greater ſpace, and makes it fly to thoſe places where it finds the leaſt obſtacle.

LADY CAROLINE.

How does it happen, Sophia, that trees are leſs ſubject in winter than in ſummer to be broken by the violence of the wind?

SOPHIA.

The reaſon is, that in winter the trees, not being furniſhed with leaves, oppoſe leſs ſurface, and conſequently give leſs power to the wind.

LADY CAROLINE.

Why, Frederic, are eaſterly winds ſo continually dry?

FREDERIC.

Traverſing a vaſt quantity of land, and little ſea, they are charged with very few vapours.

The weſtern winds are humid; becauſe, traverſing many ſeas, they are loaded with vapours.

South winds are generally hot; becauſe, blowing from a hot country, they bring with them vapours, exhalations, and agitated particles of air, naturally cauſed by a motion which in every direction produces heat.

The north wind is extremely cold, as it ruſhes from the coldeſt regions of the earth. It brings with it ſalts, nitre, and flakes of ice, which certainly contribute to make theſe winds extraordinarily bleak; for if we place ſmall pieces of ice in the nozel of a pair of bellows, there blows from them a wind more than uſually cold.

LADY CAROLINE.

How, George, are certain plants produced on the tops of towers, trunks of trees, &c.?

GEORGE.

The wind raiſes with the duſt the ſeed, which ſhoots and buds forth. Cow-graſs and other herbs very often grow in places where we wiſh they ſhould not; becauſe their ſeeds being brought thither by the wind, afterwards vegetate.

LADY CAROLINE.

How, Kitty, are the wings of a wind-mill turned round by the wind?

KITTY.

Its four wings ſupply the place of levers, and preſent their planes in an oblique manner to the direction of the wind. The power which continually acts on theſe four inclined planes, forces them inſtantly to fly back; this is what they cannot do without turning, and making the axle-tree turn to which they are fixed.

LADY CAROLINE.

How, William, does the wind raiſe your kites into the air?

WILLIAM.

The ſtring by which we hold them is tied in ſuch a manner that their ſurfaces are always obliquely oppoſed to the direction of the wind; and then the impulſion of the air naturally tends to make them mount, by deſcribing an arch of a circle, which has for its radius the twine that is held in the hand of the perſon who guides the kite.

LADY CAROLINE.

Why are the winds more rapid and more violent upon ſea than upon land? Can you explain this Elizabeth?

ELIZABETH.

Becauſe they encounter no obſtacle upon ſea; while on land they are continually interrupted by mountains, edifices, and thick woods.

END OF VOL. II.